UNION PACIFIC RAILROAD.

REPORT

OF

G. M. DODGE, CHIEF ENGINEER,

WITH ACCOMPANYING

REPORTS OF CHIEFS OF PARTIES,

FOR THE

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CHIEF ENGINEER'S OFFICE,
OMAHA, *January* 1, 1868.

DEAR SIR: I have the honor to submit herewith the report of the engineering, land and lot departments of the Union Pacific Railroad Company for the year 1867, including the reports of division engineers, chiefs of parties, and geological assistants.

During the winter of 1866–7, Mr. Bates's party was ordered to examine the outlet from the head of Salt Lake valley to Snake river, by way of Malade river and Marsh valley, with the design of obtaining some knowledge of the rim of the basin. They examined the Malade river route sufficiently to determine its impracticability. They were snowed in a portion of the time, and were finally driven out of the Malade valley by the continuous storms and deep snows. Early in January, 1867, I sent orders to Mr. Bates, at Salt lake, to organize a party with Mr. Hodges as chief, to run a line from the point where Bear river debouches into the valley of Salt lake, around the northern point of the Wahsatch range, connecting with Mr. Reed's line in the valley of Black's Fork. Full descriptions of the surveys are given in the reports of Messrs. Bates and Hodges, and I will notice them more fully when I come to my personal examinations of that country.

In making the general organization for the surveys in 1867, the pressing work was—

1st. The revision of the location up the Lodge Pole and on the divide to the eastern base of the Rocky mountains. To this work was assigned Mr. L. L. Hills, who, before completing it, was attacked by a band of hostile Indians, and killed, some six miles east of Cheyenne.

2d. The final location of the line over the Black Hills to Fort Sanders. A party under Mr. Evans had been kept at work in the Black Hills all winter, settling upon the line to locate, observing the fall of snow, the streams, winds, &c. Mr. Evans pressed the location early in the spring, the company not giving me over two months to complete it. The location was completed, and in my opinion was far superior to the changes since made in the line.

3d. The development of the country from Fort Sanders to Green river. This work was placed in charge of Percy F. Browne, under the supervision of Mr. Evans, with full instructions to develop the country between the Medicine Bow mountains and Bitter creek on the south, and the Black Hills, Sweetwater, and Big Sandy on the north. Mr. Browne had progressed well with his work up to July 23d, when he was attacked by a band of nearly 300 hostile Indians, some fifteen miles north of Laclede station, on Bitter creek, and after fighting successfully from 12 o'clock until dark, he was shot through the body and mortally wounded. The balance of the party were forced to abandon their

stock after Browne fell, and seek safety on Bitter creek. Mr. Browne's party had been attacked twice before—once near Rock creek, when he lost one of his best men, Mr. Clarke, one of the escort, and had others wounded. The loss of those chiefs of parties was very detrimental to our work, and it required great energy to overcome the natural fears and reluctance of parties to push out into that hostile Indian country.

4th. The development of the country between Green river and Salt Lake valley, reaching north to Snake river; also, a revision of Mr. Reed's line, if it was found the most practicable for location. To this work Mr. Bates was assigned, with two parties, Mr. Hodges's and his own. The loss of Mr. Hills and Mr. Browne forced me to take Mr. Bates and his party east of the Green river, to enable me fully to develop the country between Green river and Fort Sanders. This was a country comparatively unknown, but what little knowledge I had of it convinced me that through some portions of it, north of the stage road, and away from the foot-hills that border the great range of mountains reaching from the head of the Cache la Poudre to Echo Cañon, known as the Laramie, Medicine Bow, Elk, Sage creek, Bridger's Pass and Uinta ranges, we should seek a route for our road. A full examination of this country proved that my view of it was correct. The parties got into the field early, with pretty strong escorts, and were progressing remarkably well with their work, when the combined attacks of the Indians, apparently along our whole line, not only on the parties far west, but on our graders, &c., the killing of our chiefs, the depletion of our escorts, &c., virtually broke up our work, forced me to change my orders, and to use the parties wherever we could do so to advantage.

Upon the killing of Mr. Hills I left Omaha, with a view of taking direct charge of the parties in the field, to examine personally the line, and such portions of the country as I had never before gone over. I left the end of the track, at Julesburg, the 28th of June, accompanied by Mr. Blickensderfer, jr., who had been assigned by the President to the duty of determining the eastern base of the Rocky mountains, under section 20 of the act of Congress of 1862, giving subsidy for building the Union Pacific railroad and its branches; also, by General J. A. Rawlins, chief of staff of the United States army; Major Dunn, aide-de-camp; John R. Duff; General Myers, chief quartermaster department of the Platte; Mr. Rogers, Mr. John E. Corwith, and Colonel S. Seymour, consulting engineer, who was accompanying, under the direction of the company, Mr. Blickensderfer, in his examination; also Mr. S. B. Reed, superintendent of construction; General J. T. Casement and T. J. Carter, government directors, with one or two of my own assistants, going out to replace the men killed; and Mr. J. A. Evans, division engineer. Most of the party were taking advantage of the escorts that had been provided for me to get safely through the country. I pushed out by rapid marches up the Lodge Pole Creek valley, examining the line, and entered Crow Creek valley, pitching our camp at the (now) city of Cheyenne.

Here I immediately combined O'Neill's and Maxwell's parties, under Mr. Evans, who pushed forward the location from Pine Bluffs to Crow Creek crossing, the work having been abandoned and the parties driven out on the death

of Mr. Hills. This was a difficult location to make, as I required that we should in no grade exceed thirty-five feet to the mile, desiring to make that the ruling grade from the Missouri river to the eastern base of the mountains. After running several lines we settled on the southerly line, entering Crow Creek valley some seven miles east of Cheyenne, following to that place, and connecting with Evans's located line over the Black Hills at the city of Cheyenne. On the completion of this location I moved west over the Black Hills, leaving Mr. Maxwell's and Mr. O'Neill's parties in the Black Hills to make some surveys desired by Colonel Seymour, and pushed out to Fort Sanders. Reorganizing our parties and escorts here, I left this portion of the work in charge of J. A. Evans, division engineer, while I pushed on to Messrs. Brown's and Bates's parties. Soon after leaving, the sudden death of Mr. Evans's wife called him east, and deprived me of his valuable services. At Fort Sanders we entered

THE LARAMIE PLAINS.

The formation of these plains, which I treat as embracing the country between the western base of the Black Hills and the North Fork of the Platte river, on Rattlesnake range of mountains, is a singular one. They are really a park, similar in formation to the Middle and North Parks, but much less elevated, the level of the plains being about 6,500 feet above the sea. On the east and north they are bordered by the Black Hills ranges of the Rocky mountains, which stretch, about due north, 150 miles to the Laramie peak, where they turn almost due west, and terminate in the Seminoe mountains, a prominent peak rising at the mouth of the Sweetwater, which comes in to the North Platte from the west, and is really the West Fork of the Platte, the North Fork of the Platte river coming in from due south. On the south they are bordered by the main range of the Rocky mountains, snow-capped the year round, and reaching an elevation of from 10,000 to 17,000 feet above the level of the sea. Timber covers these slopes to 8,000 or 9,000 feet above the sea, and then gives way to continual snow, which never, to my knowledge, has left them bare. In this range we have the prominent peaks at the heads of the Little and Big Laramie rivers, which border the North Fork, the most noticeable of which are the Medicine Bow mountains, Elk mountain, Sheep's Head, and the peaks south of North Fork Platte crossing. On the west the Rattlesnake range juts out from Elk mountain, and runs about north to the North Platte crossing, reaching only 8,000 feet in height. The North Platte cañons through the western range, in latitude 41° 56′, while the Medicine Bow cuts the eastern range at right angles, really separating that range from the foot-slopes of the northerly range of the Black Hills.

Through these plains run the Big and Little Laramie rivers, which rise in the mountains bordering the southern rim of the plains, cañon through the Black Hills just north of Laramie peak, and enter the North Platte near Fort Laramie; Rock creek, which rises just east of Medicine Bow peak, flows due north to latitude 42°, then west, into the Medicine Bow; and the Medicine Bow, which rises in the peaks of that name, flows due north to latitude 42°, then westerly,

cañons through the eastern range of Rattlesnake Hills, and enters the North Fork of the Platte river 150 miles northwest of Fort Sanders, in latitude 42° 3′. Except in the mountain slopes to the north and south of these plains, no timber exists of any importance. The plains are covered with a growth of bunch and buffalo grass, and, as you get away from the foot-hills of the mountain ranges, you find numerous lakes, the most important being Cooper's lake, two or three miles long to one wide, strongly impregnated with alkali, the borders of which are impassable at most seasons of the year, destitute of vegetation and overgrown with sage brush and greasewood.

From this description of the country, it is plain to be seen that our line is necessarily confined between the range of mountains on the south and the foot-hills of the Black Hills on the north.

The indications of snow and the lack of water in parts of this country caused me to seek the lowest elevation on the plains, and, clinging as closely as possible to the water-courses, by following the Laramie, Rock creek, and perhaps the Medicine Bow, to obtain a line away from the high mountains, unexposed to drifting snows, that would be adjacent to water, and enter the coal-fields near Rock creek. The lack of fuel indicated that we should follow the valley of that creek upon reaching it, in order to avail ourselves of that great formation and supply ourselves with fuel. Orders were accordingly sent to Mr. O'Neill, as soon as he finished the location to the mouth of the Little Laramie, to run the lines above indicated.

From the Medicine Bow crossing Mr. Browne had run two lines—one down the Medicine Bow valley, which indicated the most desirable route, as it avoided crossing the Rattlesnake Hills, but which, for reasons that will appear hereafter, he abandoned, and found a line reaching from the summit of the eastern range of the Rattlesnake Hills, about 8½ miles north of Fort Halleck, in latitude 41° 50′, at an elevation of 7,124 feet above the sea and 555 feet above Medicine Bow, which pass has since been named Browne's pass, and is now known as such. From this summit to the North Fork of the Platte he followed down Mary's creek, which cañons through the west range of the Rattlesnake Hills and reaches the North Platte five miles north of the mouth of Pass creek, in latitude 41° 46′. I was satisfied, from my examination, that Browne's line could be reduced to a grade not to exceed 60 to 75 feet between the Medicine Bow and the North Fork of the Platte, and this made us more anxious that O'Neill's surveys might prove a success.

We laid at the North Fork of the Platte two or three days, in which time I gave the country a pretty thorough examination, following the Platte to the point where it cañons through the west range of the Rattlesnake Hills, and determining, in my own mind, that Mr. Browne had got the only outlet to the North Platte from the mouth of Rock creek to this cañon on the south, Mary's creek being the only creek heading in the eastern range of the Rattlesnake Hills and flowing westerly to the Platte within these limits. I also examined the approach to Browne's line from the northwest, thinking that Bates might be forced finally to connect at some point near Browne's crossing, instead of making his connection further west, near the divide of the continent. Subsequently,

from letters written to me by Mr. Blickensderfer, who crossed the Platte near the mouth of the Medicine Bow river on his return, I ordered Maxwell to run a line down Martha's creek, entering the Platte north of the Rattlesnake cañon, in latitude about 42°. I also ordered Mr. Bates to run a line all the way down the Medicine Bow valley to its junction with the North Fork of the Platte.

Maxwell's line was, for most of the distance, far superior to Browne's, having a lower summit to cross, and with lighter grades; but the crossing of the west range of the Rattlesnake Hills was so objectionable that, on my return trip, after personal examination of the lines and surveys, I became satisfied that Browne had examined this country fully, and had not pushed his surveys in that direction for the same reason that I was obliged to abandon the lines run by Maxwell and Bates. The death of Browne before I could reach his party, with the loss of notes and all the information he had obtained in a thorough reconnoissance of that entire country, added greatly to our labors, and in many cases forced us to cover the same ground twice.

At the North Fork of the Platte Mr. Appleton joined me. He had had charge of Mr. Browne's party since his death. The party was some 40 miles west, unable to go forward for want of water, with their horses gone, their escorts used up, and apparently with no alternative but to back out of the country that Browne was killed in while endeavoring to get a line through. They were, however, in good spirits, and I had no doubt could soon be put on their feet again.

After giving the country north and south such examination as I desired, and after sending orders to O'Neill, Maxwell, and Hodges, I determined to push west to Browne's party, and endeavor to reach Mr. Bates, and with their two parties develop the

BITTER CREEK PLAINS.

These plains are bounded on the east by the North Fork of the Platte and the Rattlesnake mountains; on the north, by the Seminoe mountains, the Ice Gap range, and the Sweetwater Hills, all of which border the Sweetwater, which runs to the foot of the northerly slope; on the west, by Green river; on the south, by the main chain of the Rocky mountains, the Bridger's Pass range, the Bitter Creek range, the Black Butte, &c. Running diagonally through these plains, from southeast to northwest, is the main divide of the continent, depressed here and losing its mountainous appearance, in altitude some 7,000 feet above the level of the sea. It is a singular formation, stretching as it does for 100 miles from Bridger's pass, on the south, to the southeast point of the Wind River mountains, on the north, a high, rolling prairie or plateau, destitute of water and limited in vegetation. This entire plain, 200 miles east and west, and from 40 to 100 miles north and south, has no living streams traversing it, and but few living springs throughout its entire extent. It is bordered on the east by the North Fork of the Platte; on the south, by Sage creek and Bitter creek; on the west, by Green river; and on the north, by the Sweetwater; surrounded by living rivers, yet within its limits there rise no tributaries to any

of these streams, which flow the year round, and in August, when I crossed it, we travelled days and nights without water except what we hauled with us.

Another singular fact connected with the formation of this great plain is that it is composed of a succession of independent basins, each having its own drainage, which is concentrated at its greatest depression in ponds and lakes, that, in some portions of the year, become quite large, but generally, during the dry season, evaporate and become dry. These secondary basins are from 50 to 100 feet below the level of the surrounding country until the main divide is reached, and then we enter the great basin formed right in the centre of the main divide, known as Reed's basin, or Dodge's basin; its extent being about 25 to 30 miles north and south, and from 10 to 20 east and west. When I crossed this basin it was dry, the bed or lowest depression in it being about 300 feet below the surrounding country. It was a surprise to us, as we expected, on reaching the main divide of the continent, to strike tributaries of the Bitter creek, or Green river, and there obtain a continual ascending grade from the Platte going west, until the summit was reached, and then a continual descending grade until Green river was reached. After examining the country in the vicinity of the North Fork of the Platte, I determined to push west in about latitude 41° 50′ to 56′ along the line run by Mr. Browne to the summit, and then endeavor to find an outlet to the west that was feasible for our purposes, flanking the Sage Creek range of mountains by the north, and Duff's Peak, Red Butte, and other isolated mountains in these plains on the south. We succeeded in obtaining a good country to Separation creek. This creek rises in the Bridger's Pass range, flows north, and loses itself in the broad plain or depression on the north border of the Bitter Creek plains. This depression is so marked and distinct that it becomes a prominent feature of the formation.

The main valley of these depressions rises near the South Pass butte, and extends east along the southern foot-slopes of the Sweetwater Hills, Ice Gap, and Seminoe mountains, narrows down, and its drainage runs to a basin near Red Butte point, in about latitude 42° 3′.

At Separation creek Mr. Bliekensderfer, jr., and his party left me, with the intention of going east along the foot-slopes of the Black Hills and north of the Medicine Bow river. I informed them that it was impracticable for them to do it with the train, having pushed through that country years before. They, however, obtained a good route east by taking the Sandy Gap, or Fremont's cart pass of 1849, when he came down the Medicine Bow with his carts, and worked over into the Sweetwater valley by the Seminoe Gap. The morning that we parted I, accompanied now by General Rawlins; Major Dunn, his aid-de-camp; Mr. Duff; Mr. Corwith; my geologist, Mr. Van Lennep, and Mr. Appleton, chief of Brown's party, (after giving Appleton's party instructions to work back to the Platte and review a part of their line run, and to seek an outlet to the north towards Seminoe mountain, as I had determined to push Bates's party, when I met them, through into the upper north valley,) struck west, to seek water and a crossing of the divide further north, taking the old Cherokee trail. I followed this trail to the summit, finding water in lakes and a country

that would afford a good line. I reached the divide of the continent in about latitude 42°. Pushing over into the Red basin I soon found that we were at fault in all our heretofore formed opinions of the country, and were really descending into a basin instead of the waters of Goose river. In this basin I met Mr. Bates and his party, who had got into the basin, got out of water, (had been out for three days,) and had been forced to retire with his party to the last water on his line. A portion of his party and escort had come very near dying from the use of stagnant or poisonous water from one of the lakes in Red Desert basin. He had with him a reconnoitring party hauling water for his men with their teams, and had calculated and was running a due line from the end of his line to Browne's line, at the divide of the continent, endeavoring to develop the country, and if possible find water, so that he could get his line over it. Upon meeting him and comparing notes of the north and west formation of the plains, I soon comprehended the make of the country, changed his orders, instructed him to abandon his present line and seek an outlet to the Platte further north, get into the broad valley that I have described above as skirting the foot-slopes of the Sweetwater mountains, and endeavor to obtain a feasible line from the mouth of the Big Sandy to Red Butte point, which would keep him in the vicinity of the 42d parallel of latitude, and with the lateral line that I ordered run, and the southern line being examined by Browne's party, would effectually develop these plains, bring out their prominent features, and discover to us the true line across them; determining then, on my return, to give the northern portion as thorough an examination as I had the southern. Leaving Mr. Bates there, I pushed out, at 12 o'clock at night, for water. Taking a westerly course by night, with Pilot Peak for my landmark in the day, we endeavored to find an outlet over the western rim of Red basin that would lead us to Bitter creek, as I saw plainly that it was all-important to cross these plains on the shortest possible route that would carry our line from running water to running water. Following the Cherokee trail, we soon got entangled among the cliffs and precipices at the head of the middle fork of Bitter creek, and worked our way as well as we could into Bitter creek valley, striking it at Point of Rocks. This examination satisfied us that to obtain a practicable line into Bitter creek valley or to Green river by this outlet, we must turn out of Red basin further east, and before encountering the rough, impassable country bordering the heads of the middle and north forks of Bitter creek. The divide or high land at the head of these streams really forms the west rim of Red basin. I accordingly started Mr. Appleton back up Bitter creek with his small escort, with instructions to find an approach from Bitter creek to the basin that would give us a low summit and a feasible line; to develop the entire country between that point and the north fork of the Platte on the east, and the valley down which Mr. Bates was running on the north. He succeeded in doing this during the fall and early winter, though with great hardship and suffering, often being without water for days, and also without fire or wood. He nevertheless did the work fully and successfully. He met the question and solved it.

On reaching Bitter creek I followed it along the line run in 1864 by Mr. Evans. The country is so marked here, so broken, that there is no question as

to the proper route of the road, if it sought Green river by the Bitter creek route; and we pushed on rapidly to Green river, reaching the crossing August 12th, where Mr. Hodges of the Salt Lake party met me, and I immediately commenced the examination of the line and route heretofore run by Messrs. Reed, Bates, and Hodges, to overcome the Wahsatch range of mountains and enter the Great Salt Lake basin.

Mr. Reed in his surveys had demonstrated that our line must seek Salt Lake valley north of the Uinta range of mountains. We were, therefore, confined by that range on the south, and the north rim of the basin on the north.

The country to be examined, therefore, no matter whether the approach was made from the mouth of Bitter creek, or as high north as the mouth of the Big Sandy, or, as was afterwards ascertained, as far north as South Pass, which covered all the ground on which any of our lines could approach Green river, was that portion of the eastern slope of the rim of the basin drained by Henry's fork, Black's fork, and Harris' fork of Green river, and of the western portion drained by Weber river, Bear river, and their tributaries.

The singular formation of this country was, that after passing the rim of the basin we struck Bear river, heading far south in the Uinta and Wahsatch ranges, running almost due north to Soda springs, or Port Neuf gap, latitude 42° 30′, suddenly bending to the south and running as far south again as latitude 41° 30′, and emptying into Great Salt lake. Within this bend of Bear river lies the Wahsatch range of mountains, a spur of the Uinta, rugged, bold, and narrow, the approach to them from the east, anywhere near the head of Bear river, or south of Yellow creek, being by a descent from the summit of the rim of the basin; but from points north by tributaries of Bear river it would require a great ascent in a short distance, while the descent from the summit to the Wahsatch west was sudden. The country to the west suddenly gives down, with no available slopes for holding up our grades. All the streams heading in the Wahsatch often cañon through spurs and present formidable obstacles for us to overcome. At the northerly point of the Wahsatch, Cape Horn, the rim of the basin opens out to the drainage of Snake river without any perceptible summit, and is known as the Soda springs, or Port Neuf gap. The topography of the country has so plainly indicated this route north, and the route by Bear river, as a means of avoiding the Wahsatch entirely, that Mr. Hodges had been instructed to run the line from Salt Lake City up Bear river to the intersection of Reed's line at the point of crossing Bear river, but its great length, being from 80 to 100 miles longer than the Weber valley line, caused me to abandon the line, for the grade obtained, though greatly reduced, in no way compensated for the extra distance. A careful examination of the north point of the Wahsatch mountains indicated a route over them by way of Hams' fork, Hodge's pass, Bear Lake valley, Martin's pass, and Cache valley, to the north point of the Bear river arm of Great Salt Lake. The season was so far advanced when the route was discovered that it was too late to run a line over it this fall, but orders were issued to have a line run as soon as weather would permit, in 1868.

The approach east and west to Martin's pass, through the Wahsatch, is so short that I do not anticipate a line that will be as feasible as the Weber valley line. On the Weber valley line the great obstacles to be overcome were the long tunnel at the head of Echo cañon, the heavy grades, and also the tunnel and heavy work in the Weber river narrows and cañon. To avoid the Echo cañon tunnel great effort was made to get from Bear river into Weber by some other stream, by Lost creek or one of its branches; but the instrumental survey of all the approaches for miles north demonstrated that the Echo cañon line was the best. Instructions were then given, after a personal examination of the line, to avoid the tunnel and lower the grades, if possible, by seeking the cañon by other ravines. Mr. Hodges in this was successful, and his line, as located, reduces the tunnel to 600 feet, and the grades to 90 feet. I am confident, however, that the work here, by a more careful location and study, can be reduced still further, and I hope the curvature reduced.

On reaching Salt Lake our trains, equipments, &c., needed repairs, and I camped at Camp Douglas to enable our transportation to be refitted and our supplies replenished, devoting most of my time to an examination of the valley and a study of the country west. I may say that a careful examination convinced me that our true line west is north of Salt Lake, and that if the Bear river arm of the lake could be crossed in about three miles distance, in shallow water, it is better to do so rather than to overcome the high grades and elevations of Promontory Point, with the heavy work involved.

Desiring to examine the approaches from our railroad to Snake River valley, with a view to a branch or through line to Portland, Oregon, and Puget's sound, and also desiring to settle beyond a doubt the question of the feasibility of any route to Reed's pass, in the Humboldt mountains, from South pass, or any point north of Bitter creek, superior to the route we then had, I determined, though late in the season, to return that way and give that country a thorough reconnoissance.

We left Salt Lake City with one company of infantry added to our escort, under command of Brevet Colonel Mills, a very energetic and efficient officer, who, during the entire trip, rendered us valuable service. We marched rapidly north on the stage road leading to Idaho, passing through the numerous towns that border the lake, and reached Bear River bridge September 6. Sending my teams around, I followed the bend of the river through the cañons, watching closely Mr. Hodges's line, passing successively the cañons at the north, the Fellows cañon, and the volcanic formation at the northerly bend of Bear river. Bear River valley is generally one to three miles broad, occasionally spreading out into independent valleys, such as Cache, Bear Lake, &c. It is hemmed in by the Malade and Snake rivers and Green River mountains on the north and east, and the Wahsatch on the south and west, Bear river doubling the Wahsatch and watering both its eastern and western bases. The valley is generally a succession of table lands, which often require heavy grades and work to reach. However, a feasible line in grades, curvature, and alignment could be got up it, but no cheaper than the Weber Valley line.

At its northerly bend, "Cape Horn," the formation is volcanic. The old

craters still exist there. The earth and ledges of rocks show wide crevices, which are very deep. Soda springs, superior to any known in the world, exist at its northerly bend in abundance, and pour out a flood of pure, sparkling soda-water, the finest I ever drank. From Bear River valley there are several openings to Snake river, known as Marsh's valley, the Port Neuf gap, and Blackfoot gap. I examined them all, and all are feasible for any road running north or south. I selected the Blackfoot route, and pushed over to the waters of Snake river. After passing the north rim of the basin the country changes, the valleys become more level, wider, and more luxuriant in the growth of vegetation. The northern slopes of the mountains are finely timbered. The streams are full of fish—salmon, trout, &c. The Snake River mountains and Bear River mountains run out spurs north and south, extending north to Snake River valley. They are high and precipitous. The streams draining them and flowing north to Snake river are all divided and separated by the spurs of these mountains. There is no difficulty in following the valleys of any of the streams into Snake River valley, but when you undertake to cross the country at right angles to the drainage, it is an impossibility. The mountains are so high and the distance in which to overcome them is so short, that no one would think of endeavoring to get west through this country from the South pass by any line north of Hodges's pass, latitude 41° 40′, via Bear River valley. The entire feasibility of a railroad from several points on our line to Snake River valley, and thence to Montana, Idaho, Oregon, and Washington Territory, was fully demonstrated. It would be by far the best line from the Atlantic to the Pacific, would avoid the high elevation of the Wahsatch and Sierra Nevadas, with their heavy grades and troublesome snows, and no doubt ere long it will become the great through route from the northwest, and control the trade and traffic of the Indies.

Having satisfied myself as to the approach to the Pacific by this route, I turned due east, with the South pass as an objective point, and crossing into Salt River valley, followed it to its source, camping on the evening of September 14 at its head, prepared to make an effort to cross the numerous ranges of mountains between it and Green river. The next day, upon ascending the mountains, it commenced snowing, and for several days we struggled over the mountains in blinding snows, our stock without feed, and our trains often hauled up the mountains by the infantry. The road was horrible, and it had to be built by an advanced pioneer corps. At one time it looked very much as though we would be entirely blocked up by the heavy snow that was falling. We crossed seven distinct ranges, and on the 19th succeeded in getting part of our troops down into the Piney, a tributary of Green river, a portion of our train having been left on the last mountain and the stock driven forward to obtain grazing. The mountains are very high and precipitous, with very few passes over them. They are covered with fine forests of pine. The valleys lie deep, and the streams find their way through them by long, narrow cañons, that man or beast can hardly penetrate. During the high-water season most of the streams would afford sufficient water to run logs from their sources to Green river. The heads of the Piney, La Barge, Bitter Root, White Clay, Marsh,

Horsehead, and other tributaries of Green river and New Fork, have heavy forests of pine and spruce, and we shall have brought to our line by way of Green river an immense lumber and timber business from this region. These pineries lie from 100 to 150 miles north of our crossing of Green river, and that river during nearly all the spring and summer months affords sufficient water to run ties, logs, &c., to our crossing.

After reaching Green river we struck north of west across the country to the base of the Wind River mountains, following them around to the South pass, and entered the Sweetwater mines, this year discovered and opened. The Indians had been so bad that very little prospecting had been done. A few quartz veins had been opened. Only a district of country some 20 miles in diameter has been prospected, and enormous yields of gold have already been obtained. The mines we visited were those on the tributaries of the Sweetwater, at the eastern base of the Wind River mountains, the head of Wind river, and the Porpogies. I have no doubt but that this belt of country is a continuation of the gold belt discovered by me in 1865, on the Big Horn mountains, Powder river, and Black Hills. When developed it will support an immense population and bring to the traffic of the road a business that to-day cannot be estimated. Portions of this country are susceptible of cultivation. The valleys of Wind river, Porpogies, Big Horn, and the eastern base of the Big Horn mountains are favorite wintering grounds of the Indians, and some twelve years ago, when examining the country for a railroad line, I found concentrated here all the friendly Plain tribes north of the Platte. The Wind River mountains on the north and west, and the Big Horn on the east, form an immense park, sheltered from the cold winds and heavy snows of that country, while the Sweetwater valley that borders this country on the south is generally for from three to five months in the year impenetrable on account of the deep snows. In June, the prospectors informed me, they crossed the Willow and Sweetwater on snow bridges. An examination of the Sweetwater valley and adjacent country convinced me that the opinion of this country that I had always advanced was correct—that it was impracticable for a railroad, the routes south having lighter work and easier grades, while, even if comparing favorably with the Bitter Creek route or the Bates route, its winds and deep snows would drive us from it; and the further fact was to be considered, that after crossing the divide of the continent here, we would be forced as far south as Hodges's pass, latitude 41° 40′, or Echo cañon, to get a feasible route west, so that nothing would be gained by following the valley of the North Fork of the Platte and the Sweetwater, with its high foot-hills and numerous cañons.

We followed down the Sweetwater with our trains, while I examined the country to the south, crossing over to the northerly point of Red Basin, to Bates's line, and connected there my reconnoissance with my westward trip.

The Bitter Creek plains extend to within 10 miles of the South pass, and are for the entire length of the Sweetwater valley only 10 to 20 miles off. We passed through the Seminoe gap a few days behind a heavy body of Indians that had wintered in the mountains, and from whom we had suffered the most

of our difficulties during the past season. At Red Butte springs, on the Plant's road, I struck Bates's and Appleton's trail, and their line, and then moved east, crossing the west range of the Rattlesnake Hills west of the North Fork of the Platte, pushing through them on the Blickensderfer trail over a pass known as the Sandy Gap pass, or Frémont's pass of 1849. Having visited this section of country years before, I was familiar with it, and struck east as fast as possible, meeting Mr. Bates's party at Lumbard's spring, (as named by Frémont,) and Mr. Maxwell's party on the North Fork of the Platte, some eight miles south of the Medicine Bow. Messrs. Bates and Maxwell were seeking outlets to their lines west of the Rattlesnake Hills, and had no means of reaching a connection except by the cañon some 10 miles north of Browne's crossing, or by Sandy gap, both of which I considered impracticable; but as Mr. Maxwell had obtained a very good line over the eastern range of the Rattlesnake Hills, with light work and easy grades, I instructed him to make connection with Browne's line by way of the cañon, and with Bates's line by way of Sandy gap, and locate on the best line east to the crossing of the Medicine Bow. Mr. Bates was instructed to continue his surveys, and make connection by way of Sandy gap on the west, and Medicine Bow valley on the east.

Mr. Bates had been devoting the past three weeks in a reconnoissance of the country, with pack mules, between the Medicine Bow river and the North Fork of the Platte, following up Kellogg's Fork and Bates's Fork, and had also given the North Fork of the Platte cañon through the Black Hills an examination. He reported the country high, broken, and impracticable for any railroad line.

Leaving my escorts here, I pushed on over the line run by Maxwell to an examination of the northerly line that I had ordered to be run by O'Neill, from Fort Sanders to the mouth of Rock creek. I found this line feasible and practicable, and ordered it to be located. The only objection to it is the great curvature in Rock creek valley. That stream is very crooked, and a line following it necessarily has great curvature, distributed, however, in easy curves.

The lines run, as presented by the division engineers, in their reports that accompany this, are divided into two general lines.

1st. *Via Browne's line.*—From Fort Sanders, latitude 41° 16′, down the valley of the Big Laramie river, crossing to Rock Creek valley; down it to the Medicine Bow, latitude 41° 54′; then to Browne's pass in the Rattlesnake Hills, latitude 41° 50′; then down Mary's Creek valley to the North Fork of the Platte, latitude 41° 46′; then to the summit of the continent by way of Rawlin's springs, Separation creek, and Dodge's pass, latitude 41° 43′; thence to Bitter creek by the south point of Red Desert; then to Green river by Bitter Creek valley; and then to the rim of the Basin by Black's Fork and Muddy Creek valley, over the Wahsatch and down Echo to Weber, and down Weber valley to Great Salt lake.

This is the general line that, after a full comparison with all the others that had been run, and after personal examination, I adopted for location, and its grades, alignments, &c., are as follows:

TABLE OF GRADES.

Browne's preliminary lines from Fort Sanders to North Fork of Platte; also preliminary line from North Fork of Platte river to Great Salt Lake City, adopted for location; O'Neill's adopted located line from Fort Sanders to North Fork of Platte river.

	Level miles.	0 to 10 feet per mile.		10 to 20 feet per mile.		20 to 30 feet per mile.		30 to 40 feet per mile.		40 to 50 feet per mile.	
		Ascent.	Descent.	Ascent.	Descent.	Ascent.	Descent.	Ascent.	Descent.	Ascent.	Descent.
Adopted line from North Platte river to Salt Lake City	59.80	13.80	33.50	37.5	31.10	27.20	27.00	9.80	28.40	11.26	17.14
Browne's preliminary line from Fort Sanders to North Fork of Platte	19.48	6.25	7.00	6.26	8.69	4.10	8.20	5.31	8.0	4.0	4.83
Total grades on Browne's and Reed's lines from Fort Sanders to Great Salt Lake City	79.28	20.05	40.50	43.76	39.79	31.30	35.20	15.11	36.40	15.26	21.97
O'Neill's adopted line from Fort Sanders to North Fork of Platte	26.875	3.598	11.6	3.6	16.8	7.0	14.7	5.0	10.6	8.3	14.6
Adopted line for location from North Fork of Platte to Great Salt Lake City	59.80	13.80	33.50	37.5	31.10	27.20	27.00	9.80	28.40	11.26	17.14

Browne's preliminary lines, &c.—Continued.

	Level miles.	50 to 60 feet per mile.		60 to 70 feet per mile.		70 to 80 feet per mile.		80 to 90 feet per mile.		Total ascent in feet.	Total descent in feet.	Total miles.
		Ascent.	Descent.	Ascent.	Descent.	Ascent.	Descent.	Ascent.	Descent.			
Adopted line from North Platte river to Salt Lake City	59.80	11.50	14.70	5.60	7.10	7.50	12.30	6.0	12.1	.....	.....	374
Browne's preliminary line from Fort Sanders to North Fork of Platte	19.48	3.52	4.0	5.0	3.26	3.09	2.0	....	....	1,075	1,648	102
Total grades on Browne's and Reed's lines from Fort Sanders to Great Salt Lake City	79.28	15.02	18.70	10.60	10.36	10.59	14.30	6.0	12.1	5.402	8.242	476
O'Neill's adopted line from Fort Sanders to North Fork of Platte	26.875	2.9	.....	1.9	.....	.....	.....	....	....	1,081	1,723	128
Adopted line for location from North Fork of Platte to Great Salt Lake City	59.80	11.50	14.70	5.60	7.10	7.50	12.30	6.0	12.1	.....	.....	374

2d. *The Bates and Maxwell lines.*—The Bates line, diverging from Browne's at the mouth of Rock creek, latitude 41° 54′, runs down the valley of the Medicine Bow to its mouth, latitude 42° 3′; over the western range of the Rattlesnake Hills, by Sandy Gap Pass; thence to Red Butte Springs, latitude 42° 3′; thence west by the Bitter Creek Plains valley, at the foot of the Sweetwater range of mountains, generally in parallel of latitude 42°, crossing the divide of the continent about 40 miles southeast of the South Pass in latitude 42° 11′, crossing Red Basin near its centre, and crossing the North Fork of Bitter creek near its head, passing the west summit by Saddle Butte and North Pilot Peak, reaching Green river, at the mouth of the Big Sandy, in latitude 41° 54′; thence

across the heads of the tributaries of Black's Fork, and connecting with the adopted line at the mouth of Ham's Fork. Grades, alignments, and distance on this line from the Medicine Bow are as follows :

Level.	0 to 20 feet per mile.		20 to 40 feet per mile.		40 to 60 feet per mile.		60 to 80 feet per mile.		80 to 90 feet per mile.		Total ascent in feet.	Total descent in feet.	Total miles.
Miles.	*Asc.*	*Des.*	*Asc.*	*Des.*	*Asc.*	*Des.*	*Asc.*	*Des.*	*Asc.*	*Des.*			
27.88	45.96	54.64	11.97	21.34	16.95	9.67	6.47	4.83	2.00	5.70	24.79	22.38	207.38

Maxwell's line is only a secondary line to Bates's, between the mouth of Rock creek and the mouth of the Medicine Bow, crossing the Rattlesnake Hills between Browne's and Bates's line, and is the best line over the Rattlesnake Hills, but is impracticable west in consequence of having to overcome the western range of the Rattlesnake Hills, which Browne's line avoids. The secondary lines to the main line run are, the Cherokee Trail line, striking off from Browne's line at Separation Creek and uniting again in Red Basin with several approaches to Bitter creek, and several lines east of the Medicine Bow. Grades, alignments, &c., on this line are as follows :

	Level.	0 to 20 feet per mile.		20 to 40 feet per mile.		40 to 60 feet per mile.		60 to 80 feet per mile.		Total ascent in feet.	Total descent in feet.	Total miles.
	Miles.	*Asc.*	*Des.*	*Asc.*	*Des.*	*Asc.*	*Des.*	*Asc.*	*Des.*			
Appleton's line; North Fork Platte to Bates' line	7.04	3.44	7.14	3.56	4.73	2.08	1.13	1.13		314	265	30.34
Evan's Road line	14.11	5.81	10.20	5.82	4.75	5.85	6.70	1.10	1.55	581	672	55.91

The grades, distance, elevation and depression on the Bear river line, and the several approaches to the Wahsatch summit run by Mr. Hodges, are as follows :

	Level miles.	0 to 20 feet per mile.		20 to 40 feet per mile.		40 to 60 feet per mile.		60 to 80 feet per mile.	
		Ascent.	Descent.	Ascent.	Descent.	Ascent.	Descent.	Ascent.	Descent.
Hodges' Bear River line.....	62.80	53.38	18.73	44.78	17.33	19.26	7.58	6.57	4.08
Hodges' Lost Creek line over Wahsatch	1.53	0.50	.....	1.96	14.35	5.07	0.95	0.76	2.63

	Level miles.	80 to 90 feet per mile.		90 to 100 feet per mile.		100 to 116 ft. per mile.		Total ascent in feet.	Total descent in feet.	Total in miles.
		Ascent.	Descent.	Ascent.	Descent.	Ascent.	Descent.			
Hodges' Bear River line.....	62.80	12.05	4.96	0.38	.....	.....	.....	3,946	1,814	251
Hodges' Lost Creek line over Wahsatch.	1.53	.....	.....	.....	.....	.....	7.76	1,655	715	36.56

Summing up the tables for a general comparison shows the following result:

Table of grades.

	Level miles.	0 to 10 feet per mile.		10 to 20 feet per mile.		20 to 30 ft. per mile.		30 to 40 feet per mile.		40 to 50 ft. per mile.		50 to 60 ft. per mile.	
		Ascent.	Descent.	Ascent.	Descent.	Ascent.	Descent.	Ascent.	Descent.	Ascent.	Descent.	Ascent.	Descent.
Adopted line, partially located, from Fort Sanders to Great Salt Lake City	86.6	17.3	45.1	31.1	47.9	34.2	41.7	14.8	39.0	19.5	31.7	14.4	14.7
Browne's preliminary line from Fort Sanders to North Fork Platte	19.48	6.25	7.00	6.26	8.69	4.10	8.20	5.31	8.0	4.0	48.3	3.52	4.0
Bates's preliminary from Medicine Bow river to Green river	27.88	.....	.....	45.91	54.64	.....	.....	11.97	21.34	.....	.....	16.95	9.67
Appleton's line from North Platte to Red Butte spring, intersection Bates's line	7.04	.....	.....	3.44	7.19	.....	.....	3.56	4.73	.....	.....	2.08	1.13
Appleton's Cherokee Trail line	14.11	.....	.....	5.81	10.29	.....	.....	5.82	4.75	.....	.....	5.85	6.70
Hodges' Bear River line	62.30	.....	.....	53.38	18.33	.....	.....	44.78	17.33	.....	.....	19.26	7.58
Hodges' Lost Creek line over Wahsatch mountain	1.53	.....	.....	0.50	.....	.....	.....	1.96	14.35	.....	.....	5.07	0.95

	Level miles.	60 to 70 ft. per mile.		70 to 80 ft. per mile.		80 to 90 ft. per mile.		Total ascent in feet.	Total descent in feet.	Total in miles.	90 to 100 ft. per mile.		100 to 116 ft. per mile.	
		Ascent.	Descent.	Ascent.	Descent.	Ascent.	Descent.				Ascent.	Descent.	Ascent.	Descent.
Adopted line, partially located, from Fort Sanders to Great Salt Lake City	86.6	7.5	7.1	7.5	12.3	.....	9.0	58.08	83.17	480.8	.....	.....	.....	.....
Browne's preliminary line from Fort Sanders to North Fork Platte	19.48	5.0	3.26	3.09	2.0	.....	.....	10.75	1,648	102	.....	.....	.....	.....
Bates's preliminary from Medicine Bow river to Green river	27.88	.....	.....	6.47	4.83	2.00	5.70	24.79	22.38	207.38	.....	.....	.....	.....
Appleton's line from North Platte to Red Butte spring, intersection Bates's line	7.04	.....	.....	1.13	.....	.....	.....	314	26.5	30.34	.....	.....	.....	.....
Appleton's Cherokee Trail line	14.11	1.10	1.00	.....	0.55	581	672	55.91	.....	.....	.....	.....	.....	.....
Hodges' Bear River line	62.30	.....	.....	6.57	4.08	12.05	4.96	39.40	18.14	251	0.38	.....	.....	.....
Hodges' Lost Creek line over Wahsatch mountain	1.53	.....	.....	0.76	2.63	.....	1.05	16.55	715	36.56	.....	.....	7.76	.....

After the thorough examination of this country that has been given it there is no question in my mind as to the line to be adopted. It is No. 1, Browne's line, it being the shortest, with the least curvature, lightest grades and cheapest work, the least length of road without running water, the most accessible to building material, and the least liable to obstruction from snow.

The snow question has been carefully considered. A line is often laid on account of snow that would seem to violate some of the well-established principles of engineering as applied to lines where snow obstructions are not a question, and the question often arises in the minds of engineers why a line is so

laid, when seen in summer, when were it viewed in winter, with its deep, drifting snows, the cause would be perfectly apparent. For this reason, and a great many others that I might mention, a change of line after being located by the engineer who has given personal attention and study to the question right on the ground, during winter and summer, no matter how questionable it may seem to some, criticising it from casual observation and without hardly any knowledge of the reasons controlling its location, is dangerous, and so far all general changes that have been made without the sanction of the engineers have been injurious to the line, to the road, and a great and permanent loss and cost to the company. All lines can be improved by study and with proper time, but after that has been given by competent engineers, radical changes made with only a partial knowledge of the country are always dangerous, and generally a damage instead of a benefit.

Mr. James A. Evans, division engineer, has had charge of the location of the line and of the surveys to Green river. I call attention to his report upon the line over the Black Hills. The changes of line that he discusses were made by the company against my earnest protest.

The delays and detentions of my parties in the Black Hills were almost fatal to my efforts to develop the country west of the Laramie, and prevented me from obtaining a location to the North Fork of the Platte, or Bitter creek, this year, as I had intended; and while I bow most respectfully to the decision of the company, I must say that any detention of work in 1868, on account of want of located line, will rest solely upon them, and not upon me, for while I had overcome the embarrassments consequent upon the killing of my chiefs of parties and the breaking up of my parties by the Indians, I had not the power to control parties held from their proper and arranged work by order of the company. I shall strain every nerve to get the location so advanced in the spring of 1868 as to be far out of reach of construction corps, but success will depend upon the severity of the weather.

I also call attention to the reports of Messrs. Bates, Hodges, Appleton, Maxwell, Van Lennep, House, &c. They have all taken that interest in our work, endured the hardships, exposure, and run the risk of life, that no person would have done whose heart and mind were not in the business.

The parties have run lines as follows:

INSTRUMENTAL LINES.

	Miles.
Evans's party	215
Browne and Appleton's party	358
Hodges's party	472
Maxwell's party	210
Bates's party	420
	1,675

Number of miles of reconnoissance, 3,310.

Number of miles of travel of parties, 5,193.

During the entire year I have received that aid and courtesy from the military authorities which have characterized their conduct towards us ever since the road was commenced. In no instance have they failed, as promptly as possible, to respond to our requests, and we are under great and lasting obligations to them. To General C. C. Augur, commanding department of the Platte; General J. A. Rawlins, chief of staff, United States army; General J. C. Gibbons, commanding Fort Sanders; General J. H. Stevenson, commanding Fort David Russell; Colonel Mizner and Colonel Mills, commanding Fort Bridger; Colonel Lewis, commanding Camp Douglass; General W. Myers, chief quartermaster department of the Platte; to the staff officers and departments of the posts on the plains, and the commanding officers of the escorts, we are under especial obligations, and I desire here to acknowledge them.

REPAIRS ON COMPLETED ROAD.

The party of engineers who have had charge of repairs on the road have been under the direction and supervision of J. E. House, division engineer. All repairs have been made and new structures built by Webster Snyder, esq., general superintendent.

On April 1st the company took possession of the road, accepting it from the contractors, and Mr. Snyder was made general superintendent. From April 1st to June 24th the road was operated by the company from Omaha to the North Platte; 290 miles; from June 24th to November 1st, from Omaha to Julesburg, 377 miles; from November 1st to November 18th, from Omaha to Hillsdale, 495 miles; and from November 18th to December 1st, from Omaha to Cheyenne, 516 miles.

At Omaha, Elkhorn, Shell creek, Columbus, Grand island, and various other points, the track has been raised, new bridges constructed, larger water-ways built, and old structures enlarged, to meet the requirements of the surface drainage of the country, as shown in the floods of April, the highest and most extensive ever known in this country, and it can now be safely said, that a repetition of these floods would not materially injure the road or delay the running of trains.

Where the snows of the winters of 1866–7 blocked the road, the cuts have been widened, new fences built, and the road prepared, as far as practicable, to meet the snows of the past winter; and, so far, they have admirably succeeded.

New side tracks have been laid down at Diamond's, Jackson, Clark, Chapman, and McPherson's stations, and it will be necessary to construct, ere long, intermediate side tracks between all the main stations in order to accommodate the business of the road.

Two spans of 100 feet each of Howe truss, with stone pier and abutments, have been built at Columbus, over the east channel of Loup Fork, (which is dry at all seasons of the year except in high water,) and the embankment on the low bottom raised above high water. It is thought this will avoid, in the future, the dangerous ice gorges and extreme high water caused by them at this place. Where foundations of trestlework were not considered safe, as

against the scour of streams and dry runs in high water, pile foundations have been put in, rendering the structure perfectly safe. Coal houses, with a capacity of 600 tons each, based upon stone foundations, have been erected at Grand island, Kearney, Plum creek, North Platte, Ogallalah, and Julesburg. Preparations have been made and material provided for building similar houses at Sidney, Antelope, and Hillsdale. New tank houses have been erected at Diamond's and Chapman, and old houses have had stone foundations provided. It will be necessary to place additional tank houses at all new stations and side tracks, and wind-mills should be provided for all where any considerable amount of water is used.

A temporary pile bridge was erected over the Missouri river to accommodate the trade and traffic during the winter months, costing about $10,000. Its advantages more than compensated for its cost.

Mr. Snyder has certainly shown great energy and ability in bringing the road and equipments up to the standard he has, and the road bed shows more fully the condition of the road, work done, &c., than I could state here. It receives the decided approval of all professional railroad men who travel over it.

Besides all the repairs on engines, cars, &c., executed at the shops, the company have built 3 first-class passenger cars; 4 second-class passenger cars; 4 baggage, express and mail cars; 58 box freight cars; 91 platform cars; 35 hand cars; 1 bridge car; 20 caboose cars; 1 paymaster's car. And they have on hand, for the 517 miles of road operated by the company, the following equipments: 53 locomotives; 9 first-class passenger cars; 4 second-class passenger cars; 6 baggage and express cars, 243 box freight cars; 449 platform cars; 99 hand cars; 1 bridge car; 20 caboose cars; 25 coal cars; 1 president's car; 1 officers' car; 1 paymaster's car; 1 cooking car; 1 pile driver and engine car.

The above is exclusive of the large amount of rolling stock owned and run by the contractors for building the road.

The amount of freight and number of passengers transported over the road since the company assumed charge, viz., April 1st to December 31st, 1867, is as follows:

Total number of passengers	15,022
Number of passengers carried one mile	3,381,088
Total number of tons of freight moved	25,900,845
Over line for contractors:	
Total number of men hauled one mile for contractors	1,740,681
Total number of pounds of freight transported over road	54,144,318
The total amount of government service performed in the transportation of troops, freight, mail, mail agents, and telegraph service, is	$812,819 73

The above is given to show the amount of business done over the road from April 1st to December 31, 1867, and only indicates what may be the business of the road when completed.

LANDS.

Our lands may be considered as divided into two classes—those that are available for settlement now, and those that need continual water, or irrigation, to render them susceptible of cultivation. Of the first class we can count all the lands for 200 miles west of Omaha, nearly 2,000,000 acres. Of the second class we have all the lands in the Platte from near Fort Kearney to Julesburg, 180 miles, of which we can say that 1,152,000 acres can be made immediately available without much expense to the company, as the Platte river runs centrally through this number of acres, and it could all be irrigated by simple acequias or ditches, taken out by any one and at any point. To make the 1,152,000 acres between these two points available, the canals, ditches or acequias would have to be carried back on to the bluffs, and until the Platte valley proper is settled and farmed the benefit to the company would not justify the cost. At the eastern base of the mountains there are about 600,000 acres that could be irrigated. In the Laramie plains, from the Black Hills to the Bitter Creek plains, there are about 1,000,000 acres that could be readily and cheaply irrigated, either by the purchaser and farmer, or the company, as, flowing at suitable distances through these lands, at right angles to their length, are the Big and Little Laramie rivers, Cooper's creek, Rock creek, the Medicine Bow river, and the north fork of the Platte, all flowing sufficient water to irrigate every acre.

From Green river to Salt Lake valley there are about 2,000,000 acres in the valleys of Green river, Henry's, Black's, and Ham's forks, the Muddies, Bear river, Weber river, and in the valley of Great Salt lake proper. All these lands can be readily supplied with water from the above-named streams, not only for irrigating purposes, but these streams all furnish fine mill privileges, and flow plenty of water the year round for both purposes, so that we might answer that to-day the company have lands to the amount of 6,752,000 acres that could be placed in the market as fit for present settlement, and susceptible of immediate cultivation without any more cost or delay to the settler than the farmers of Colorado, Utah and California have suffered in opening up their farms. Irrigation once introduced, and all farmers prefer it, as it gives a never-failing supply of water, and furnishes at all seasons of the year a proper moisture for the land, preventing any failure of crops from droughts. Experience has demonstrated the fact, in all irrigating countries, that settlement and the cultivation of trees render less necessary, every year, the watering of the land by artificial means. Double the rain falls in Colorado and Utah to-day that fell 10 to 20 years ago, before the settlement of that country, and as improvement and settlements increase along our line, the necessity for irrigation will decrease, and thus render available for settlement, and a source of profit to the road, millions of acres of land on these plains that are looked upon to-day as barren waste, fit only for the growth of cactus, sage-brush, and greasewood, but which are, in fact, as shown in Utah, from actual experiment, and as shown by chemical analysis, some of the best producing lands of the continent.

During the year the lands of the road have been put in shape, the records commenced, maps made, the lists prepared, and everything got ready for entry

by the company, and the placing of them upon the market. Conflicting titles have been examined, and the rights of the company protected. The papers and records of the land department have been prepared by Mr. O. F. Davis, who is experienced in such matters, from a long connection with the land department of the United States government, and the system which will be completed early in 1868 will be a simple, concise, and effective one, both for the road, and for sale, examination and appraisement.

DEPOT TOWNS.

The depot towns have been laid off as fast as the line has been located and built—Julesburg and Cheyenne being the most prominent. The former has been rapidly built up. The "roughs" of the country congregated at Julesburg, jumped the town, and rendered the place a hell in the eyes of all respectable men. It was a long time before the company could even hold possession of the property. At Cheyenne this state of affairs was avoided by the prompt, determined action of General Stevenson, and while he had control of the police of that country law was enforced, respectable people protected, and business thrived. Under this state of affairs Cheyenne, in a few months, sprang up from nothing to a place of 5,000 inhabitants. The sale of lots and entire control of that business has been under Mr. House, he attending to it in connection with his duties as division engineer in charge of the Omaha office. Separate reports, maps, &c, have been made to the company from time to time, relating to the matter, and it is not necessary for me to go into further details here.

TIMBER.

The company and the country have labored under a misapprehension as to the timber along or in the vicinity of the road. The fact that for the entire length of the road very little timber is growing immediately upon the line, has created the belief that there is very little in that country. Assuming that there is only sufficient for the purpose of fuel east of the Black Hills, we can safely estimate and fully demonstrate that from that point west the pineries are so extensive that they will supply all that country with lumber, the road with ties, &c.

The belt of timber commencing in the Black Hills follows parallel to the line on the south, covering the slopes and filling the cañons of the Rocky mountains that form the southern view of the Laramie plains, the Medicine Bow mountains, the Elk, and all the numerous spurs jutting out from the main range, while the heads of the Laramie, the Medicine Bow, the North Fork of the Platte, &c., rise in these pineries, and furnish by their waters cheap transportation for their productions to our lines, less than 30 miles away.

Passing the north fork of the Platte, the pineries south of Sage creek, at Bridger's pass, Black Butte, and bordering Current creek, will all be made available some day. No stream flows from them towards our line, but from points on the line they may all be reached by 20 or 30 miles travel. West of Green river, the slopes of the Uinta and Wahsatch, and the immense cañons of that

bold range, are covered and filled with fine timber. The heads of Henry's Fork, Black's Fork, Bear aud Weber rivers, are in immense timber groves, and readily accessible to the line.

On the north we find the tributaries of Green river, New Fork, &c., heading iu the finest pine, hemlock, and spruce forests anywhere east of the Great Basin, and all of the forests on the easteru slopes of the Bear river, Snake river, and Green river ranges of mountains are available to us, as their productions can be carried to Green river and floated to our crossing. I hold, and am confident that time will justify the opinion, that the road will receive an immense revenue from this source, as soon as the demaud is such as to justify the development of this invaluable source of wealth.

STONE.

After passing Cheyenne, and in Lodge Pole valley, stone for bnilding purposes is at no time far distant from our line. It exists in all its formations—the granite, sienite and trap of the Black Hills, the limestone and sandstone of the Laramie and Bitter Creek plains, with the granite, saudstone, and limestone of Utah, all more or less suitable for our purposes. Mr. Van Lennep, in his report, says:

Stones for buildiug material are abundant. The portion which has a want of it, on the surface, is the region between Fort Sanders and Rock creek. The harder sandstones of the Rattlesnake Hills will afford very good material; of these, some outcropping at the crossing of the North Platte and iu its cañons are good, also iu the cañons of Pass creek. Material of very great streugth and durability, if required, could probably be found on or at the foot of Elk mountain. Further west, the quartzite found near Rawlin's spring is one of the strongest aud most durable materials that could be found; while a few miles west of this point are sandstones of good quality. With our present knowledge, the limestone occurring at this point will be valuable, from the total want of the material from Fort Sanders and west to Bitter creek, beyond Salt Well station; it is, however, probable that limestone occurs in Bitter creek near Laclede station, as fossil shells are found there, some of which I have seen covered with limestone. There may be a lack of suitable rocks near the summit and along the Red Desert, but on the south and southwestern sides of it there are sandstones which would likely be suitable for the purpose. On Bitter creek, both the sandstones between the coal beds and the grit cappiug them, but especially the grayish sandstone found between each formatiou, will be found good for such purposes. Good material was seen at several points west of Green river. At Fort Bridger they obtain a good material, and from the west, after crossing the Muddy, to Bear river, there is no lack of it. Some thin layers of limestone are found near Pioneer's Hollow. At the head of Echo valley there are limestones, but further down, though many rocks are not good, there is a great variety of sandstoues that will be found suitable. In both the Weber cañons there is a great choice of very good material. North of Fort Bridger, beyond the Muddy, is found much sandstone good for the purpose.

COAL.

Lignite, of excellent quality, in beds of 5 to 11 feet in thickness, exists in the lower basins, estimated at 5,000 square miles. Its most eastern limit is about 15 miles east of Rock creek, a branch of the Medicine Bow, and outcroppings show themselves in Rock creek, the Medicine Bow, the North Fork of the Platte and its numerous tributaries, in the basins of Bitter Creek plains, on Bitter creek, and iu the basins of the Sweetwater Hills.

In the Wahsatch country the outcrops are found on Henry's, Black's and Ham's Forks of Green river, on Bear river for its entire length, and on Weber river, which flows into Great Salt Lake.

The brown coal, or lignite, burns with a bright red flame, giving out a fair degree of heat, leaving scarcely any ashes, and is quite desirable as a fuel for domestic purposes. The Union Pacific railroad cuts this vast bed of coal nearly in its centre, traversing it through its entire length from east to west, and the cars, which generally go loaded west, and empty east, can distribute the coal over the entire length of the road, supplying fuel to the whole country adjacent to our line, thus removing an objection that has heretofore been considered nearly fatal to its settlement. The geologists generally give from 12 to 20 per cent of water in this coal, and from 58 to 68 per cent. of carbon. A portion of the heat is lost in making steam, in the amount it takes to change water to steam. Notwithstanding this objection, we discover at a glance that with from 58 to 68 per cent. of carbon, the lignites of the interior of our continent are far superior to any other ever discovered in other portions of the world.

The geologists agree that these western lignites are undoubtedly tertiary. Those of the upper Missouri river have been shown by Doctor V. L. Hayden to be of that age, both from vegetable and animal remains. The connection of the lignite deposits has been traced by Hayden and others uninterruptedly for 80 miles beyond Fort Laramie. They then pass north beneath the White River territory, and come to view on Powder river, the Cheyenne, Yellowstone, and upper Missouri; while in the south they pass beneath the high elevations or ridges over which Lodge Pole creek runs, and make their appearance on Lone Tree, Coal, Cache la Poudre, Saint Vrain's and Boulder creeks, pass beneath the Arkansas divide, and appear along the eastern base of the mountains at Rattoon pass, the Venango, and to an indefinite distance west.

When we reflect that we have from 10,000 to 20,000 square miles of lignite beds in the centre of a region, and adjacent to a country, where, for a radius of 500 miles in every direction, there is little fuel, either on or beneath the soil, the future value of these deposits cannot be overestimated.

IRON.

Beds of iron are scattered all along the route, mostly limonite and hematite. They lie in numerous beds, and in masses upon the surface of the ground, varying in size from one pound to several tons in weight. The nodules and concretionary masses, when broken, show regular concentric rings, varying in color from yellow to brown, looking sometimes like rusty agates, and yielding from 60 to 80 per cent. of malleable iron. These numerous deposits of limonite beds are not all. There is magnetite iron in places, at several points along the line, solid mountains which yield from 80 to 90 per cent. of magnetite iron, and if this great mineral fuel of the plains—the lignite, which is found in such abundance adjacent to the iron, and often overlaid with it—can be made useful for smelting purposes, these lignite and iron-ore beds will exert an influence over the wealth and greatness of the west that the iron and coal of Pennsylvania do over the east.

GOLD AND SILVER.

The gold and silver mines of Colorado are so well known that I will not endeavor to give a description of them, but only to remark, that the building of the Union Pacific railroad has reduced the cost of labor, and of the transportation of material and machinery, to such an extent that mines that have heretofore laid idle are now being worked by the old stamp process, where it is estimated that only about one-half of the gold and silver is saved. The new mines that are being discovered may well attract our attention. They are immediately adjacent to our lines, and all trade, travel and traffic will go over our road to and from them.

The prospects on the south, at the heads of Rock creek, the North Fork of the Platte, Current creek, and their tributaries, constantly indicate mines that will be thoroughly tested and finally worked with a profit.

In Utah, the silver mines of Rush valley, extending away to the Humboldt, are only waiting our advent to be opened and give employment to thousands of people. The cost of labor, of obtaining and transporting so far machinery, &c., has heretofore hindered people from doing more than to test the quality and supply. There is no doubt but that they are extensive, and they will probably prove second only to Nevada in richness.

During this year the Sweetwater mines were developed. They have been discovered for years, but were never thoroughly tested until 1867. From a personal examination in 1865, and again in 1867, I am satisfied that this mineral belt extends as far east as the heads of the Cheyenne, White Earth, Powder and other streams. On all these streams our prospects of 1865 proved very rich, and had it not been for the hostilities of the Indians and the prohibition of government, the Powder River country and the Big Horn mountains would have been thoroughly prospected and thousands of miners would have flocked there. The Sweetwater mines proper are confined to the heads of the Sweetwater, Wind river, Porpogies and Big Horn rivers. These mines have been pretty thoroughly prospected. The miners have obtained a hold there, and cannot now be driven out. At least 20,000 people will flock there during 1868, and that whole country will soon be overrun by the energy and perseverence of this hardy class of frontiersmen. From this source alone the local traffic of the road will return a good income. I have no doubt of the richness of these mines, and of the feasibility of working them. The formation of the country, its rocks, &c., indicate that the entire region extending from the point of the Wind River mountains to the northern range of the Black Hills is rich in the precious metals.

TRADE AND TRAFFIC OF THE ROAD.

When we reflect that China, Japan, Hindostan, and the East India islands contain five hundred millions of people—nearly half the population of the globe—the importance of this trade is apparent. For a long time the exportation of the precious metals to that country has ranged from 25 to 35 million per year, chiefly in silver bullion, in return for which they have sent back

tea, cotton, silk, and spices, and the list is continually enlarging. The importation of merchandise from 13 Chinese ports in 1865 was $210,000,000, while the island trade must have vastly swelled the sum. Europe has reaped the advantages of most of this trade, and will be forced, if it desires to retain it, as soon as our line is completed, to take it across our continent by our railroad. American enterprise and energy seeing this, have already established steamship lines from the Pacific coast to all that country, and at this time New York is only 40 days from Yokohama, 15 of which are required between San Francisco and New York, including 1,000 to 1,200 miles of staging. Within two years, upon the completion of the road, it will be reduced to six, and give us from New York to Japan only 30 days. London is to-day 45 days distant from Shanghai, with 3,000 miles of land travel to overcome between it and the capitals of the east. It is not probable that this gap of sterile country will be bridged for years, and London must remain, as at present, 40 to 45 days distant from Shanghai, giving us a clear advantage of 15 days, a fact which makes for all Europe our route the shortest and quickest way to the east. With the transportation of all this vast trade secured that has heretofore been foreign to our country, let us turn to that of our own nation.

The Pacific slope to-day has less than 1,000,000 inhabitants, and they are yielding $50,000,000 to $60,000,000 of bullion yearly, with quite that quantity of grain, besides immense yields of wool, hides, wines, timber, and everything that can be produced in that delightful climate and fertile soil. The best vegetable productions of the Mississippi and Missouri valleys are dwarfed in comparison with those of California. The wheat crop of California and Oregon for 1867 was 25,000,000 bushels, and far exceeded in value the gold product of both States. The shipments from the port of San Francisco in one year loaded 160 vessels, and to China alone were exported nearly $10,000,000 in merchandise and minerals. With this state of prosperity now—with this favorable showing for the business of the road—what must it be when the road is completed from the Atlantic to the Pacific? Population and capital will pour over it in a steady stream until the 1,000,000 of inhabitants become 6,000,000, and the wealth of the country is multiplied ten-fold.

With this through traffic let us look at the local. To-day Idaho has 30,000 inhabitants. The products of its mines are counted by millions. Montana has a population of 40,000 to 50,000, and the products of her mines are daily on the increase. The rich valleys of the tributaries of the Missouri river are becoming one vast farm. Utah claims 100,000 as its population—industrious, every man, woman, and child, with tasks allotted—fast growing into a mining and manufacturing, as well as an agricultural people. Colorado claims 60,000. The embryo Wyoming has already 20,000. And all this country is rich in mines, in salts, in soda, in sulphur, copper, lead, iron, and coal.

When emigrants can be transported to the cheap and fertile lands on the Pacific coast and along the interior, and when they can for $50 to $100 more be landed in a country teeming with mining facilities, and its future promising golden riches, it may be depended upon that they will go there. It may be safely presumed that there are 100,000 people waiting to-day in the Atlantic

States for the completion of this road, and 50,000 in the Pacific, some to revisit their former homes, some to seek new ones, and others desiring to visit a country that for years has been upon everybody's tongue.

It would therefore appear that, as soon as completed, the traffic over the Union Pacific railroad will be limited only by the capacity of the road California, Washington, Oregon, Nebraska, Idaho, Montana, Utah, Wyoming, and Colorado will soon fill up. Their precious metals, their rich soil and unequalled climate, will inaugurate a business and a trade that will soon demand another track, and which no man to-day can even estimate. The road's receipts from a nation's civilization and prosperity may be gauged by its facilities for travel and transportation. "Good roads," says John Stuart Mill, "are equivalent to good tools;" and it is of no consequence whether the economy of labor takes place in extracting the produce of the soil, or in carrying it to a place where it is to be consumed. Without the Union Pacific railroad the country west of the Missouri river would be a burden to the government, and almost an uninhabitable waste; with it, it will soon be an empire, and one of our principal elements of power and strength.

I am, very respectfully, your obedient servant,

G. M. DODGE, *Chief Engineer.*

OLIVER AMES, Esq.,
President Union Pacific Railroad Company.

Report of James A. Evans, Division Engineer.

ENGINEER'S OFFICE, UNION PACIFIC RAILROAD,
Fort Sanders, Dakota, January 1, 1868.

SIR: In accordance with custom I have the honor to present this my annual report of operations during the year past as engineer in charge of the location.

The instructions given me in February, 1867, required me to move west as early as the 1st of March, and to locate the line from the crossing of Crow creek over the Black Hills, and thence westward.

I left Omaha with party on the 6th day of March, the weather on that day being favorable, and promising to continue so. On the evening of the day we started we encountered a snow storm which delayed the train several hours in reaching North Platte station, the then terminus of the road. No other train passed over the road in several days, and my impression now is that but three trains made trips in as many weeks. The march of the party was extremely tedious, and considerable suffering was experienced. It seemed that the whole energy of the winter had concentrated itself in the month of March, so much so that one party leaving Omaha about one week after us remained at North Platte for weeks, some members returning to Omaha. The state of the weather and the quantity of snow in the mountains made it impossible to commence operations before the 22d day of April. On the 20th of May the location was carried to the Laramie river.

Finding it necessary to go to Omaha at this time, and knowing your anxiety about the location over the mountain range, I made to you the following report:

ENGINEER'S OFFICE, UNION PACIFIC RAILROAD,
Omaha, June 4, 1867.

DEAR SIR: The location of the line from Crow creek to the Laramie river being complete, I respectfully submit the accompanying profile and record of field-notes.

It may safely be presumed that in all cases where lines extend over mountains they will present some prominent characteristic features. The one under consideration is no exception to that general rule.

The most noticeable features of the line are its remarkably smooth profiles and the small amount of mechanical structure required. Taking into consideration the amount of elevation overcome, there is little hazard in stating that it is unprecedented in the history of engineering. This desirable result is not obtained by excessive curvature. The accompanying table of alignment is much more favorable than usually occurs where gradients are heavy and elevation great. The estimate herewith submitted is based upon the assumption that no rock work need be encountered on the first 11 miles of work from Crow creek crossing west, the line for that distance occupying the valley of *an usually dry* tributary of that stream.

From that point to where the stratified rocks intersect the metamorphic, the material will be found of a mixed character; when the cutting is light, the material will be earth; when it exceeds six or eight feet in depth, a conglomerate formed from the disintegration of the granite with the admixture of lime will be met with. This rock will be easily moved. In construction care should be taken in making the material count economically in embankment, as when the material is mixed earth and rock, and put in bank indiscriminately, there is a loss of fully 50 per cent. of what the rock would measure in bank. In other words, to every 100 cubic yards of rock embankment 50 cubic yards of earth could be added, which would, of course, be a loss of so much material, and as the profile over this part of the line shows an excess of embankment over excavation, it seems very necessary that a proper adjustment of material should be made.

From station 950 to station 2,200 but little earth will be found in excavation on the line, and when borrowing is contemplated it will be necessary to leave the centre line to obtain it. Over this portion of the line temporary trestle work is estimated, and it may be necessary to give the excavation in cutting additional width in some cases. The material over this distance is homogeneous, with the exception that from stations 1,100 to 1,220 dikes of trap cross the line diagonally. This rock will be found more compact, and, consequently, more difficult to move than on the balance of the line. Aside from the short distance indicated above, the rock will not be difficult, being a granite imperfectly metamorphosed, the feldspar largely predominating, and the cementing material imperfect, so that it weathers badly and is easily broken up.

At station 2,200 red sandstone is met with. From thence to the Laramie river it is the only rock in place. This rock can be moved so easily that it will require a separate specification.

In specifications for the entire work some provision should be made for loose rock. Much of this material can be obtained from points contiguous to the line and placed in embankment.

I have thought it prudent to incorporate in the estimate an item of fencing. Although, in consequence of the line occupying the summit of divides for its greatest distance, it is comparatively free from snow obstructions, still there are points where the precaution of fencing becomes absolutely necessary. It is believed that the expenditure of the item given will make it safe, so that the line can be operated at all times.

The sections are not numbered on the profile as they are in the estimates, for the reason that when the connections east are made a different numbering may be adopted.

Respectfully submitted.

JAMES A. EVANS,
Division Engineer Union Pacific Railroad.

General G. M. DODGE,
Chief Engineer.

Estimate.

Number of section.	Earth excavation.	Solid rock.	1st-class masonry.	2d-class masonry.	Timber in trestle.	Truss bridging.
	Cub. yards.	*Cub. yards.*	*Cub. yards.*	*Cub. yards.*	*M. B. M.*	*Lineal feet.*
1	13,992		230	81	123,600	150
2	23,639			121	800	
3	11,297				92,350	
4	20,152			68	38,000	
5	14,124			105	600	
6	17,886			44	37,500	
7	18,825	8,570		270		
8	26,655	5,000		175		
9	32,810	4,070		195		
10	6,097	24,516	958	130		350
11	5,234	18,356			52,500	
12	8,785	15,520				
13	8,588	9,860		53	280	
14	500	12,094		121	300	
15	2,274	8,080				
16	20,322	1,670				
17	2,400	20,400			173,000	
18	6,023	6,048	390		48,000	
19		23,156		79		
20		28,216	1,620			500
21		40,762				
22		30,530	320			
23		13,100	350			
24	4,522	4,612		79	680	
25	16,744					
26	12,669	4,000	120			80
27	22,000	7,000			14,200	
28	6,300					
29	14,500		60			40
30	18,680		120		18,900	
Total	335,018	285,560	4,168	1,521	600,710	1,120

Earth excavation, 101,090 cubic yards, at 35 cents	$35,381 50
Earth excavation, 233,928 cubic yards, at 45 cents	105,267 60
Solid rock, 285,260 cubic yards, at $3	856,680 00
First-class masonry, 4,168 cubic yards, at $20	83,360 00
Second-class masonry, 1,521 cubic yards, at $15	22,815 00
Timber in trestle, 600,710 M. B. M., at $50 per M	30,035 50
Truss bridging, 1,120 lineal feet, at $100	112,000 00
70,000 lineal feet of snow fence, at 80 cents	56,000 00
	1,301,539 60
Add 10 per cent	130,153 96
	1,431,693 56

Distance from Crow creek to Laramie river, $57\frac{63}{100}$ miles; $24,842 86 for grading.

ABSTRACT OF ALIGNMENT.

	Feet.
Tangent	227,914
$\frac{1}{4}°$ radius	6,980
$\frac{3}{4}°$ do.	1,087
1° do.	20,989
$1\frac{1}{2}$ do.	
2° do.	16,687
$2\frac{1}{2}°$ do.	709
3° do.	11,963
4° do.	10,137
$4\frac{1}{2}°$ do.	1,249
5° do.	6,756
Total distance	304,471

Percentage of curve, $25\frac{1}{7}$. Per cent. tangent, $74\frac{6}{7}$.

Table of grades.

Ascending west.			Descending west.		
Per station.	Per mile.	Distance in feet.	Per station.	Per mile.	Distance in feet.
1.7	89.76	56,840	1.7	89.76	24,150
1.66	87.65	6,600	1.62	85.53	6,200
1.61	85.00	4,600	1.57	82.9	8,100
1.53	80.78	3,500	1.44	76.0	1,600
1.5	79.2	3,000	1.4	73.92	2,800
1.43	75.5	5,700	1.34	70.75	8,000
1.42	75.	1,900	1.27	67.05	2,200
1.38	72.86	6,300	1.23	64.94	2,600
1.37	72.33	2,200	1.12	69.13	3,500
1.36	71.80	6,200	1.00	52.8	1,300
1.35	71.28	5,400	0.81	42.77	1,500
1.32	69.7	2,200	0.8	42.24	5,950
1.31	68.2	7,200	0.7	36.96	2,100
1.27	67.05	1,400	0.67	35.37	2,800
1.22	64.41	2,700	0.65	34.32	1,400
1.21	63.9	1,900	0.55	29.04	2,200
1.2	63.36	1,400	0.54	28.51	5,000
1.08	57.02	5,100	0.5	26.40	1,700
1.05	55.44	1,900	0.47	24.81	1,500
1.00	52 8	7,700	0.42	22.17	3,200
0.91	48.04	4,400	0.4	21.12	3,000
0.88	46.46	4,000	0.35	18.48	1,900
0.85	44.88	8,100	0.26	13.72	4,300
0.66	34.85	3,500	0.286	15.10	2,800
0.58	30.62	1,900	0.23	12.14	1,800
0.4	21.12	2,100	0.2	10.56	3,200
0.3	15.84	600	.....	.....	.....
0.28	14.78	600	.....	.....	.....
0.25	13.20	1,500	.....	.....	.....
Level	.....	9,060	Level	.....	29,967
		169,500			134,767

Total elevation, 2,202 feet; total depression, 1,129 feet; total distance, 57.63 miles.

The foregoing report was made before any material was moved. The result proved that much less rock than anticipated was encountered. Much of the material that, when undisturbed, seemed to be solid rock, proved to be of so soft a nature as to be easily ploughed.

During my short stay at Omaha, we received the sad particulars of the murder of Mr. L. L. Hills, who at that time was in charge of a party making location over the divide between the valleys of Lodge Pole and Crow creek, as this part of the line was required by the construction parties. At your request the party under my immediate charge in the Black Hills was ordered eastward as far as Pine Bluffs, on Lodge Pole creek, and in connection with Mr. Hill's party, the location from there to the initial point of the Black Hills location on Crow creek was completed. As this part of the work was accomplished under your immediate charge, and subject to your personal supervision and inspection, it does not seem necessary to go into matters of detail with regard to it.

The reports made of location over the Black Hills would require no further reference were it not for the fact that a very radical change has been made on the eastern slope. This change commences at station 480 of the line to which the preceding report refers, converging again finally at station 1710, at the summit of Evans's pass.

The change is not an entire one for the whole distance, but the stations given above are the extreme points, all changes that have been made occurring between them.

Work was in progress on the line originally located previous to and during the time the changes were being made.

The material moved and rendered as useless expenditure is as follows:

Earth excavation, 34,593 cubic yards.

Solid rock excavation, 1,920 cubic yards.

Loose rock excavation, —— cubic yards.

In making a comparative estimate of both lines, I shall take both profiles, presuming that the classification is the same in either case, making no deduction in either for temporary trestling or bridges, using for embankment a base of 14 feet, slopes ½ to 1, and for excavation a base of 16, slopes 1 to 1 in both cases. The figures show as follows:

	Cubic yards.	
Original location, embankment	470,387	
Original location, excavation	159,433	
		629,820
Line as changed, embankment	459,397	
Line as changed, excavation	175,179	
		634,576
Excess on line as built		4,756

Grades compare thus:

Original line, maximum grade, 89.76 feet per mile.

Line as built, maximum grade, 88.176 feet per mile.

Upon examining the comparative alignment of both, you will be able to determine whether the slight difference of grade is not more than compensated for by excessive curvature.

Table curvature.

Deflection per Sta.	Radius.	Original location.	Line as changed.
	Feet.	° ′	° ′
½ degree	11,459	23 10	
¾ degree	8,594	7 22	
1 degree	5,730	102 42	25 50
2 degrees	2,865	215 37	75 24
3 degrees	1,910	153 16	293 38
4 degrees	1,432	216 27	494 19
5 degrees	1,146	112 10	276 52
6 degrees	955		52 00
Total deflection		830 44	1,218 03

The total deflection is therefore 50 per cent. greater on the changed line than on the original location, and if the above table is scrutinized it will be seen that in curves of short radii, say from three degrees upwards, the increase is fully 130 per cent.

When we consider that, practically, curves are seldom in perfect adjustment, and that trains on grades of 80 and 90 are very often under imperfect control, the liability to accidents is very much increased, as well as the wear and tear of

the machinery and rolling stock. The line, as changed, is much more liable to obstructions from snow than the original location. It may be an interesting question to investigate, where the compensation is found for the material lost on the first and decidedly the best line; the cost of keeping an engineering party in the field during the entire season, and the still more expensive delay caused by doubts pertinaciously and systematically thrown upon everything that had been done previously by those in charge of the work. I do not hesitate to say that, had the original line been pushed through without let or hindrance, the company would be in possession of a far better line, and that their material, instead of being now at Cheyenne, at the foot of the grade on the eastern slope, might just as well be here at Sanders, and immediately available for the year 1868.

The delay referred to above was not only felt by those connected with the construction, but interfered much with the parties under my charge. They were used in running lines on the western slope, knowing well themselves that they were operating where no man of any engineering sense would ever think of using an instrument.

Notwithstanding the delay, the location was carried to eight miles beyond the Medicine Bow river, sixty miles west of the crossing of the Big Laramie river.

Maps and profiles have been furnished of all the line located.

Respectfully submitted:

JAMES A. EVANS,
Division Engineer.

General G. M. DODGE, *Chief Engineer.*

Report of Francis E. Appleton, Assistant Engineer.

SIR: I have the honor to submit the following report of surveys made by the party under my charge during the year 1867:

According to your orders, the party under the late Mr. P. T. Browne left Omaha on the 6th of March. A long and tedious journey of a month's duration brought us to La Porte, having experienced extreme cold weather and severe storms for most of the time. Having started very early in the season, we were compelled to remain a fortnight at La Porte, to render working in the hills practicable. From then, the 15th of April, until about the 1st of May, we were engaged with Mr. Evans, division engineer, in locating in the Black Hills, arriving finally at Fort Sanders, Dakota Territory, on the 2d of May, and leaving again for our western surveys on the 6th.

Starting from near the Laramie river, at station 168 of Mr. Evans's line of 1865, and station 3,365+13 of the Crow creek and Cache la Poudre line of the same year, and crossing the river, we continued with an average magnetic course of north, 53° west, over a rolling prairie to a point six miles west of Little Laramie river. From thence, bending to the west, we crossed a high ridge 2½ miles east of Cooper's creek, obtaining an 80-foot grade, descending the western slope, and thence north, 45° west, magnetic, crossing Cooper's creek and over a rolling table to Dutton's or Seven-mile creek. Two miles west of this creek we passed

through an opening in a high ridge which extends in a northeasterly direction some two miles from our line, and then branches east and north, the Pine bluffs, near Rock creek, being a continuation of the northern branch. From here we continued to Rock creek, finding a broken and bad country from four miles east of Rock Creek to that stream.

While in camp between Duttou's and Rock creek, we met with a calamity, in the loss of two of our party, Sergeant Clair, of our escort, who was killed on the 12th, and Stephen Clark, of Albany, New York, who was mortally wounded on the 13th of May, by a party of Indians, supposed to be Sioux. The circumstances you are already aware of Mr. Clark had much endeared himself by a genial and happy disposition to all the members of our party. The Indians captured, at the same time, a span of our mules, harness, fire-arms, &c. These reverses forced us to abandon our work temporarily, and move to the stage road, where we went into camp at Cooper's Creek station. From there Mr. Clark's body was taken to Fort Sanders and properly interred, Mr. Browne accompanying his remains to the post. We remained at Cooper's creek until Mr. Browne's return, about June 1, with fresh mules, &c., and then returned to our work near Rock creek. Crossing that stream we were forced to run nearly north (magnetic) for seven miles. Keeping most of the way on a smooth table, then turning northwesterly through a pass in the high ridge between Rock creek and Medicine Bow river, we followed down the valley of a small creek to Medicine Bow river, crossing it about 1½ miles above the mouth of Rock creek. Here Mr. Browne left the party, taking a small escort with him, to explore the country to the Platte, leaving orders to continue the line down the valley of the Medicine Bow. We ran down this valley 16 miles to the entrance of the cañon, where we received orders from a messenger from Mr. Browne to abandon the line as impracticable. We then went into camp and awaited his return, which took place in three days. We then returned to our crossing of Medicine Bow, Mr. Browne again leaving the party to explore a line south of the present line, and leaving it three miles west of Dutton's creek, crossing Rock creek some four miles south of our present crossing, and thus throwing out the bad country we encountered near Rock creek; thence continuing westerly, crossing the Medicine Bow eight miles above the mouth of Rock creek, and connecting with the present line ten miles west of the Medicine Bow. This exploration he was unable to make on account of the high water in the Medicine Bow, one of his escort being nearly drowned in attempting to cross that stream, a difficulty we had previously experienced in running our line down the valley. He reported a good profile between the river and the westerly point of connection of this projected line.

After backing up to our crossing we turned to the southwest, following up the valley two and one-half miles, then moved westerly over a rolling table and into the valley of a running stream, which we followed up, making a summit 16½ miles west of the Medicine Bow, Mr. Browne's explorations having decided his opinion that this was the only route by which he could get to the North Platte, and leave it on the west side, with a good line. Three and one-half miles west of this summit we struck the head of a small creek, which we followed to the Platte

river. This creek runs through a crooked cañon, in the Rattlesnake Hills, which would involve a rock-cutting 40 feet in depth and about 700 feet long, to straighten the line, which is very crooked here. It also cañons six miles east of the Platte; not badly, however. These two points are the worst features in the line between the summit and the Platte river.

We reached the river near the last of June. It was at that time so high as to render fording it impracticable, and we were forced to turn out to the main road to get on the other side. We remained a week in camp at Pass creek, making up our field-notes, and awaiting the arrival of our provision train from Fort Sanders. Leaving Pass creek on the 9th of July, we proceeded round to the west side of the Platte, a very strong, swift stream, through all this portion of the country, the current averaging from six to seven miles per hour.

We ran two crossings of this stream; the latter, made by your direction, proving much preferable. We found an old water-mark here, which would indicate 1,500 lineal feet of trestle work, and two spans of 150 feet each, to be necessary in crossing the river at this point.

Mr. Browne left us before reaching the Platte, for an exploration further west. In ascending the slope west of the Platte we obtained (with surface rock) a grade of 70 feet for a distance of 52 chains. This can probably be reduced to sixty feet per mile. From here we obtained good grades and alignment until rising a summit 22 miles west of the Platte, where there is a grade of 60 feet per mile. By crossing this ridge to the south of our present line, and within a mile of it, lower summits can be obtained and this grade thrown out. Four miles further on, the line enters a narrow cañon, and here we obtain an average descending grade of $69\frac{7}{10}$ feet for three miles, to near Separation creek. This might be helped, possibly, by turning to the south along the slope, and thereby increasing the length of the line and the curvature.

Here Mr. Browne*, who had returned four days previously, having explored the country 10 miles west of the summit of the main divide, again left us. His party were attacked by a large band of Indians near Bitter creek, and he was mortally wounded, dying the following day at Laclede station, which his party had succeeded in reaching after abandoning their stock to the savages.

Before Mr. Browne's death the line had been continued to the summit of the main divide, on the route of his first exploration. Leaving Separation creek the line runs up the valley of a dry creek, seven miles, with an average grade of 12 feet per mile, then turning into a branch of this creek, follows it until reaching a high table, on which the grades are easy and alignment good to the main summit. A grade of 60 feet for 60 stations, obtained in getting out upon the table, can be avoided by commencing the ascent lower, and the line from Separation creek to the main summit can be reduced to a maximum of 50 feet per mile, or less.

The alignment on the summit table to the point of descent on the western slope can be reduced to a straight line, or nearly so, throwing out some large angles in the present line.

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* I insert no eulogy upon Percy Thorne Browne. Those who knew him best can best appreciate how great his loss; a man without a blemish.

Descending the western slope the ground falls from the summit 145 feet in 150 stations. The grade for this distance could be reduced to 50 feet per mile, throwing out a gradient of 70 feet per mile (obtained on the present line) for 60 stations. From this point we followed the valley of a dry creek 13 miles, to the lowest point between the main divide aud the Bitter creek summits, obtaining 120 chains of 50 feet grade, a great portion of which could be reduced to 40 feet. From this point over a high, smooth bottom, with an average grade of 16 feet per mile, until we struck a long, dry creek emptying into the Red desert, some 30 miles uorth of Bitter creek; thence 10 miles up a smooth valley to the summit of of a high ridge, where we obtained some 70 feet grade, but which could, by lengthening the line, be reduced to 60 feet. From here, 12 miles to Bitter creek, the line runs down a narrow valley, and is considerably cut up by dry creeks which have cut their channels deep into the grouud; otherwise the ground is not heavy; a grade of 60 feet near the summit can be easily reduced, probably to 40 feet.

On reaching Bitter creek we were not able to fiud Mr. Evans's line of 1864, but established a branch some 3,000 feet east of Big Pond station, and on the north side of the creek.

In the following table, grades east of the Platte river are not considered, the line being nearly located to that river.

Summary of Browne's line.

Distance.	Miles.	Elevations above tide.	Feet.
Big Laramie river to Medicine Bow.	53.8	Big Laramie river	7,110
Medicine Bow river to North Platte river.	48.4	Lowest point between Big Laramie and Medicine Bow river.	6,558
North Platte to summit of main divide.	47.3	Rattlesnake hills, Browne's pass	7,131
Main divide to Bitter creek	56.0	North Platte river	6,475
		Separation creek	6,650
Big Laramie river to Bitter creek.	206.5	Maine divide, summit	7,120
Bitter creek, Big Pond station, to Green river line of 1864.	62.0	Link west of summit	6,660
		Bitter Creek ridge (summit)	7,164
		Branch near Big Pond station, Bitter creek.	6,779
Big Laramie to Green river	268.5		

Table of grades.—Browne's line.—From the Platte valley to Bitter creek.

Ascending.			Descending.			Remarks.
Miles.	Ascent in feet.	Grade.	Miles.	Descent in feet.	Grade.	
8.88	101	0–20	1.79	22	0–20	
11.68	347	20–40	2.10	61	0–40	
8.23	402	40–60	1.86	78	40–60	
2.97	195	60–72	3.20	236	60–72	
31.76	1,045	.....	8.95	397	.....	Summit of main divide.
.....	*6.59	.....	.....	.....	.....	
6.88	114	0–20	3.26	39	0–20	
3.98	132	20–40	2.86	90	20–40	
4.62	198	40–60	6.15	284	40–60	
1.21	151	60–72	1.13	81	60–72	
16.69	595	.....	13.40	494	.....	Summit of Bitter Creek divide.
.....	*2.77	.....	.....	.....	.....	
00	00	0–20	0.77	10	0–20	
00	00	20–40	4.81	148	20–40	
00	00	40–60	3.20	134	40–60	
00	00	60–72	1.15	74	60–72	
.....	.....	.....	9.93	366	.....	Bitter Creek.
.....	*1.44	.....	.....	.....	.....	

From Platte river to Bitter creek, (above table condensed.)

15.76	215	0–20	5.82	71	0–20	
15.66	479	20–40	9.77	299	20–40	
12.85	600	40–60	11.21	496	40–60	
4.18	346	60–72	5.40	391	60–72	
48.45	1,640	.....	32.28	1,257	.....	Total curvature of line 2031°.
.....	*10.80	.....	.....	.....	.....	

* Miles of level grade.

CONNECTION WITH BATES'S PRELIMINARY.

After Mr. Browne's death, according to your orders I took charge of the party which proceeded back to the Platte river and saw the second crossing of that stream already spoken of. I went on west with your own party, leaving it at Point of Rocks. On my return I found a large opening or valley opening into Bitter creek, eight or ten miles west of Big Pond station, but did not discover any practicable opening in the Bitter Creek ridge at its head. I was unable to explore this part of the country thoroughly, as our horses had nearly given out, one having been already abandoned, and our rations also falling short. From here I crossed the country to the summit of the main divide, near the crossing of the Evans road. I found no practicable opening to the summit on the eastern slope but the one followed by this road. After five days' journey from Point of Rocks we reached the party at Rawlins' springs, eight of our horses having thoroughly given out.

Starting at station 5,824 of Browne's line, eight miles west of the Platte river, we ran a line to the north and west, through a large opening, to connect with Bates's line of 1867. The ground is favorable, and grades on a located line would not exceed forty feet per mile. Some bad country that we obtained near Browne's line might be avoided by keeping nearer the Platte. As indicated on the map, a slight undulation would be unavoidable in this line. The length to connecting point is twenty-two and one-half miles.

EVANS'S PASS LINE.

Finisbing Bates's connection, we returned to station 6,717 of Browne's line, three miles east of Separation creek, and ran down in the valley of this creek, crossing it five miles north of Browne's crossing, and at the soonest point possible, obtaining a forty foot grade. Continuing in the line of my previous exploration, we crossed the main summit eleven and one-half miles west and north of Browne's summit, obtaining a summit 290 feet lower than the previous one. On this line there are two bad points—the first near station 7,500, in crossing a ridge, the alignment being bad; and the second a mile east of the summit, a seventy foot grade, with heavy work, being obtained. By using sixty foot grades, and lengthening the line in the latter case, both these points could be thrown out.

Near the summit I made an exploration to the north of our line, finding a narrow opening about one and one-half miles from it, which extended clear through, making a summit three and one-half miles west of the present summit, and, as I then judged, from 40 to 60 feet lower than it.

By turning to the right from the present line at a point four and one-half miles east of the summit, and following down a smooth valley about four miles to a lake, (Green Grass lake,) and then commencing to ascend, I am of opinion that a better line could be obtained. Such a line would necessarily connect with the present line about four miles west of the present summit. I was unable to run this line owing to the scarcity of water in the vicinity, and being fearful that I could not get the line far enough advanced to enable me to make connection with Bitter creek.

On the west side of the summit we followed the course of a dry creek, the natural grade of which for about two miles from its head is about 50 feet per mile. In attempting to get 40 feet, by keeping along the slope, we obtained rather heavy work for a short distance. We followed this valley some six miles, then turned southerly into a very large basin, which I have called the Red Desert, the ground being covered with powdered red shale washed from the bluffs. We continued south some five miles, which brought us north and west about two miles from the prominent points in this desert, known as the "Clay Buttes," but finding no opening through the Bitter Creek ridge to the west of these Buttes we turned easterly and connected with Browne's line, 25 miles northeast of Bitter creek.

While in camp on South Bitter creek, about the 10th of September, Mr. John Morgan reached us, and by your direction took charge of the party. Shortly afterwards we proceeded to a point on the line of the Evans road, and ran a line southwesterly up a promising valley some 10 miles. This we abandoned, however, as towards the head of the valley the ascent was 80 feet per mile. Mr. Morgan then made a thorough exploration of the country between the summit of the main divide on Browne's line and that of the Evans road pass. The summit is high all along, and no line over it is practicable between the two passes.

Mr. Browne's previous explorations had decided him that there was no approach to the summit on the east side, and south of his line, that was practicable with a good line.

It was after this exploration that the part of Browne's line between the summit and the point of connection with the line of the Evans road pass was run. We had previously made two attempts to run this part of the line, but were unable to do so on account of the scarcity of water, having to haul it from Bitter creek, the nearest then known of, and which was 50 miles off.

The length of the line over the Evans road pass is, from where it leaves Browne's line to its point of connection again, 55 and $\frac{38}{100}$ miles, being some twelve miles longer than Browne's line. After we had connected Browne's line we pulled out to the stage road at Barrel Springs. From there, Mr. Morgan, taking an escort, returned to Pleasant valley, eight miles west of Big Pond Station; travelled up the large valley spoken of in my exploration, and giving the ridge at its head a thorough exploration, found an opening, as he judged, from 100 to 200 feet lower than where the present line crosses Bitter Creek ridge, and four or five miles further west, the ground being more favorable for a line from the common point of Browne's and the Evans Road Pass lines to Bitter creek than the locality of the present line. The ridge here, he judged, might be overcome with nothing to exceed 50 or perhaps 40 feet grades. Having made this exploration, and our escort being rationed only to the 15th of November, we started for Fort Sanders, reaching there the 12th of that month. From there we proceeded to Omaha, discharging the party there. Maps and profiles of our summer's work have already been forwarded to you.

Table of grades on the line of the Evans Road pass, from station 6,717 *of Browne's line, and connecting at station* 9,047 *of same line* = 9,668 + 60 *of Evans Road line.*

Ascending.				Descending.		
Stations.	Miles.	Ascent in feet.	Grade per mile in feet.	Descent in feet.	Miles.	Stations.
348	6.59	98	0–20	135	11.27	595
315	5.96	176	20–40	120	3.99	211
159	3.01	132	40–50	178	3.86	204
89	1.68	96	50–60	157	2.88	152
57	1.08	79	60–73	82	1.18	62
968	18.32	581	....	672	23.18	1,224

13.88 miles of level grade; total curvature of line 1,437°.

Table of grades on Browne's line from station 6,717 *to station* 9,047.

Ascending.				Descending.		
Stations.	Miles.	Ascent in feet.	Grade per mile in feet.	Descent in feet.	Miles.	Stations.
534	10.11	165	0–20	43	3.20	169
304	5.76	169	20–40	111	3.73	197
150	2.84	87	40–50	212	4.45	235
40	0.75	43	50–60	76	1.59	84
104	1.97	124	60–73	237	3.39	179
1,132	21.43	588	....	679	16.36	864

5.45 miles of level grade.

Approximate estimate of quantities from the Platte river to the eastern point of connection of Browne's and the line of the Evans Road pass.

49,829 cubic yards excavation.
183,327 cubic yards embankment.
520 lineal feet of trestle-work.
20 lineal feet of five foot culverts.
336 lineal feet of ten-foot culverts.

From the eastern point of connection of Browne's and the Evans Road lines to the western point of connection of the same lines.

45,889 cubic yards excavation.
254,183 cubic yards embankment.
150 lineal feet trestle-work.
35 lineal feet of five-foot culverts.
696 lineal feet of eight-foot culverts.
473 lineal feet of ten-foot culverts.

From the western point of connection of the above lines to Bitter creek, Big Pond station.

35,384 cubic yards excavation.
124,721 cubic yards embankment.
860 lineal feet trestle-work.
990 lineal feet of five-foot culverts.
388 lineal feet of eight-foot culverts.
115 lineal feet of ten-foot culverts.

Total of above tables from the Platte river to Bitter creek, Browne's line.

131,102 cubic yards excavation.
562,231 cubic yards embankment.
1,530 lineal feet trestle-work.
1,045 lineal feet of five-foot culverts.
1,084 lineal feet of eight-foot culverts.
924 lineal feet of ten-foot culverts.

Line through the pass of the Evans road from its eastern to its western point of connection with Browne's line.

71,283 cubic yards excavation.
446,323 cubic yards embankment.
50 lineal feet trestle-work.
260 lineal feet of five-foot culverts.
340 lineal feet of ten-foot culverts.

TIMBER AND FUEL.

From Fort Sanders to Bitter creek there is very little timber in the vicinity of the line. Some cottonwood is found in the valleys of Rock creek and the Platte, and a few stunted cedars and pines on the adjacent bluffs. These we found also on Duff's peak, seventeen miles west of the Platte, and a very few on the bluffs bounding Separation creek. From there to the Pine bluffs on Bitter creek, four miles northeast of Big Pond station, there is no timber at all. All this spoken of is fit only for fuel. The nearest timber fit for ties and use in construction is on Elk mountains, where there is an abundance of pine, quaking asp, and fir; also, south of the stage road on the Platte river, probably some fifteen or twenty miles, where, I learn from report, there is a large amount. Logs could be easily floated down the Platte in the summer months.

Of coal, good indications were found on Rock creek, three miles north of the crossing; also near the summit of the Rattlesnake Hills, and near the end of the Medicine Bow line. At the latter place we also found indications of oil. West of the Platte we found good surface coal near Separation creek, and near the summit of the Evans road line. Also on South Bitter creek, about five miles southeast of the termination of the line, Mr. Morgan found a bed of charcoal of good quality, about five miles northwest from where the line crosses Browne's summit. Valuable minerals we found no indications of.

WATER.

East of the Platte there is sufficient; also for twenty miles west. From there to Bitter creek we found but three small springs in the country: Solger springs, near the Evans road; a small alkaline spring, nine miles east of Solger springs and a mile north of the same road, and a small spring four miles northeast of Browne's summit, where the water issues slowly from the bank. We obtained, by digging here, sufficient water for our purposes. There are some lakes in the country, though probably all dry in dry seasons. The lake west of Solger springs, with an abundance of water on the 6th of August, was entirely dry on the 1st of September. As to how deep it might be necessary to go in order to obtain water, is a question only solvable by experiment.

I have made no estimates on lines east of the Platte river, owing to the line having been located to Browne's summit, thirty miles east of that river. On this thirty miles the grades will be easy; not to exceed fifty feet for a located line, and the work light, with the exception of the rock-cutting already spoken of, in the Rattlesnake Hills.

The work done this season does not compare favorably with that of past years, owing to the dangers incurred from hostile Indians and the delays occasioned by their attacks, the great scarcity of water, and the general sterility of the country we have had to work in, thereby rendering favorable camping spots necessarily distant from the end of our line. The total amount of work done is as follows:

	Miles.
Laramie river to Bitter creek, Browne's line	206. 5
Medicine Bow line	16. 5
Connection with Bates's line	22. 5
Evans Road line	54. 7
Morgan's line	10. 0
Lines re-run, set-backs, &c	48 0
Total	358. 2
Total number of miles travelled by line party, as near as I can estimate	1, 435. 0
Total	1, 793. 2

To Mr. Collins Chesbrough and Charles H Quinn I am under many obligations for valuable assistance rendered. Maps and profiles have already been submitted to you at the Omaha office.

I have the honor to remain, your obedient servant,

FRANCIS E. APPLETON,
Assistant Engineer.

General G. M. Dodge,
Chief Engineer Union Pacific Railroad.

Report F. S Hodges, Assistant Engineer.

Great Salt Lake City, Utah,
January 1, 1868.

Dear Sir: I have the honor to submit herewith my report for the year 1867.

On the 1st of April, 1867, in accordance with verbal instructions from Thomas H. Bates, division engineer in charge of Pacific division, I left Salt Lake City and proceeded to commence the

BEAR RIVER LINE.

Bear river, rising in the Uinta mountains, after flowing northward for 225 miles, finds a vent by flanking the northern extremity of the Wahsatch mountains, and, doubling upon itself, flows southward 100 miles and empties into the Great Salt lake. Previous surveys had crossed its drainage and sought entrance into the valleys of the Great Basin by a direct route. My orders contemplated following the river throughout its course, and by a hasty line developing the principal features of the route, and obtaining the topography and natural resources of the country.

Principal features and description.—The sources of Bear river were reconnoitred by Mr. Reed in 1864, and his report included a description of its head waters from Reed's Peak to the mouth of Yellow creek. For this distance it is a mountain stream, flowing over a bed of boulders and stones It has here

attained its full size and width of 250 feet, and has no immediate alluvial bottom lands. Such is its general character for 20 miles below Yellow creek to the mouth of the cañon near Medicine Butte, where it makes a sharp bend to the west for four miles, and then flows off toward the north again. Its valley, heretofore constituted by sage-brush tables between high bluffs from one-half to one mile in width, now opens 10 or 15 miles to smooth slopes and arable soil. Its waters, previously fordable, are now from four to six feet in depth. Its course, formerly direct and swift, now becomes sinuous and sluggish, and from a former average descent of 25 to 15 feet per mile, now falls but 450 feet in the next 100 miles, or an average of 4½ feet per mile, making most of this in two series of rapids, one at a confinement of the valley just below Smith's Fork, and the other at a similar spot below Thomas's Fork. At the latter place the valley makes a sharp bend or projection to the southwest. To save distance, location crosses the river from four to six times in 20 miles. For the last 12 miles of this distance the line is confined in quite a narrow valley, where the river finds its way through a range of hills which here cross its course, making an extension of the northeast spur of the Wahsatch range. Emerging thence the line enters Bear Lake valley, traversing its northern edge for 13 miles. Thence for 13 miles more the line is again confined between the banks of a narrow valley, but location would probably keep away from the river upon the table and bench lands to Soda Springs table. For this distance of 125 miles, comprising the whole eastern end of the Great Bend of Bear river, the location would compare favorably in every respect with any portion of the line of the Union Pacific road west of the 105th meridian.

Soda Springs table is a smooth plain, varying from 2 to 10 miles wide or more, and 23 miles in length. A small settlement here just at the northernmost bend of Bear river obtains this name from the natural production and inexhaustible supply of sparkling springs of soda water, strongly impregnated and exceedingly pleasant to the taste. Sulphur springs are abundant, forming acres in extent in some localities, where brimstone can be shovelled up like soil. A crater of an extinct volcano is found here. The formation of this table is of porous trap, underlaying a thin layer of soil. Through this table the river flows with perpendicular walls of rocks, often 50 feet high, and at the west end of the table, by a series of rapids through a cleft or chasm, it makes a descent of 516 feet in six and a quarter miles, or 82½ feet per mile. At the mouth of this cañon the gap is 2,000 feet wide and 500 feet deep, with slopes of huge cubes of trap rock. In order to overcome this obstacle the line seeks descent by Trout creek, a stream eight miles long and emptying into Bear river, some 10 miles below the mouth of this cañon From thence, after five miles along the bottom lands of Bear river, the line enters the Narrows, eight miles in length, and then Cañon Connor, three miles. In the Narrows the river is shut in between the hills, and in the cañon between the mountains, where a spur from the Wahsatch crosses and forms a range heading to the north. The river falls at the rate of 40 feet per mile in places, but the slopes and tables give opportunity for a good but costly line throughout. From the mouth of the cañon the profile is very heavy along the banks and side hills for a distance of 13 miles. Owing to extreme

risk and exposure, and loss of time incurred by crossing the river at its June floods, the line was confined to one side, whereas a judicious location would cross it probably five times along this portion of the route, (including Cañon Connor and the Narrows.) Such a location would throw out the greater portion of the heavy work shown on the profiles. Through Cache valley for 21 miles nothing objectionable is found. In passing from this valley to that of the Great Salt lake, Bear river passes through Cañon House, three miles in length. This cañon is formed by a spur from the Wahsatch, crossing northward. The line leaves it at an elevation of 150 feet above the water in the river, and the work is very expensive, one-third of it being along cliffs of black limestone. This cañon may be avoided by a line one mile to the south, crossing the divide with heavy grades. The river falls at the rate of 80 feet per mile in rapids. At one spot a fall of 15 feet occurs. Thence through Salt Lake valley, 46½ miles, nothing objectionable is encountered.

A reference to the profiles and maps (scale ½ and 4 miles to the inch) will illustrate the description of the principal features and render more apparent the natural divisions of the route, as stated below.

Natural divisions of line.

Div.		From station to station.	Miles.
1	Salt Lake valley	0-2,450	46.5
2	Cañon House	2,450-2,612	3.0
3	Cache valley	2,612-3,710	21.0
4	Along river bank	3,710-4,390	12.9
5	Cañon Connor	4,390-4,540	2.8
6	Narrows	4,540-4,970	8.1
7	Fellows' valley	4,970-5,242	5.1
8	Trout creek	5,242-5,683	8.3
9	Soda Springs table	5,683-6,888	22.7
10	Along river bank	6,888-7,901	19.2
11	Bear Lake valley	7,901-8,595	13.2
12	Along river bank	8,595-9,267	12.7
13	Thomas's Fork valley	9,267-9,741	9.0
14	Narrows	9,741-9,830	1.8
15	Smith's Fork valley or Bear River valley	9,830-12,332	47.3
16	Pass	12,332-12,398	1.2
17	Yellow Creek valley	12,398-13,253	16.2
	Total		251.0

Construction and material.—For 161½ miles, or 64 per cent., viz: in the 1st, 3d, 7th, 11th, 13th, 14th, 15th, 16th, and 17th divisions, the cost of construction is light, and the material to be moved soil and gravel.

For 40 miles, or 16 per cent., in the 8th, 10th, and 12th divisions, the cost is moderate, and the material is mostly clay and gravel.

For 46½ miles, or 18 per cent., in the 4th, 5th, 6th, and 9th divisions, work is expensive, and the material clay, loose rock, black lime rock, and trap rock.

For three miles, or two per cent., in 2d division, or Cañon House, the cost is very heavy, and the material mostly black lime and slate rock.

Grades.—Fifty feet per mile is the ruling grade, occurring frequently in the line from Cañon House to Soda Springs table, inclusive.

Alignment.—Generally very good: 8° or radius of 716 feet ruling curve.

Bridges.—Fifteen truss bridges of 250 feet span, 4,000 feet trestle. Numerous culverts, stone for which is generally very abundant and convenient.

Table of altitudes.

Station.		Elevation above tide-water in feet.
	Water in Great Salt lake	4,250
0	Weber Bench	4,575
246	Water in crossing of Weber river	4,291
2,114	Water in crossing of Bear river	4,265
2,510	Water in river in Cañon House	4,358
4,350	Water in mouth Cañon Conner	4,650
4,970	Water in head of Narrows	4,925
5,680	Soda Springs table, west end	5,425
6,090	Water in Bear river at crossing on Soda Springs table	5,575
7,050	Water in Bear river east end of Soda Springs table	5,875
7,910	Water in Bear river west end of Bear Lake valley	5,990
9,140	Water in Bear river crossing at Station	6,087
9,540	....do....do	6,167
12,330	....do....do	6,418
13,250	Water in Bear river opposite station	6,740
13,253+08	Equal Reed's line, station 1,781+06	6,760

NATURAL RESOURCES.

Timber.—Timber is generally abundant in the Wahsatch range. Near Soda Springs over a large area the finest pine is found, logs 70 feet long by 2½ feet square being obtained. Near the sources of Bear river large quantities are reported by Mr. Reed in his report of 1864.

Coal.—Indications of coal were seen near Soda Springs, and on the bank of Bear river in the cañon near Medicine Butte, near division No. 16.

Lands.—Cache valley and Bear Lake valley are well settled and the finest in Utah. Division 15, called Smith's Fork valley, or Bear River valley, is unsettled, though 40 miles long by 10 broad, and mostly capable of cultivation. There are three other settlements along the route, but, like the lands adjacent, of not much importance, 1,000 square miles, or 640,000 acres, comprising the extent of available lands. Salt Lake valley is not included. That portion of it adjacent to this line between station 0, near Weber river and Cañon House, is well settled and cultivated. Ogden and Brigham City are towns of from 1,200 to 2.000 inhabitants.

Geological specimens.—Specimens of the material encountered along the route, of the different kinds of rock, mineral quartz, fire clay, sulphur, scoria, &c., have been furnished the geologist of the company, Mr. Van Lennep, to whose report for 1867 I would refer.

Topography.—High ridges and mountains shut in Bear river from near its source, where Reed's line crosses it, to Cañon House, near its mouth. A second route, entering it from the east, is referred to as the subject of the next portion

of this report. A route might be found from near Soda Springs northward, via Blackfoot or Port Neuf to Snake river, or from Cache valley via Marsh valley to same locality. No other exit or entrance practicable for a railroad exists, unless it be in the south end of Cache valley, which demands reconnoissance. (See subsequently.)

Bear river receives but two affluents of importance, Smith's and Thomas's Forks, each about 40 miles long, and rising in the high country where the rim of the basin joins the divide of the continent. Bear lake, in Bear Lake valley, is about 20 miles long by five wide, filled with trout. This lake is the reservoir of the waters from a large area of mountain country, and its outlet is into Bear river. All these streams, quite insignificant the greater portion of the year, are vastly increased in June by the melting snows, until Bear river overflows its banks and covers the bottom lands. This was the cause of great delay and expense to the outfit, and rendered progress at times very tedious. Occasionally the greater portion of the party were engaged in assisting the wagons in moving through the mud, or hanging to them by ropes to prevent their upsetting on side hills. It was found necessary to carry a small boat along, frequently used to ferry the party over the river, and at one time the wagons piece by piece.

Lieutenant W. W Bell, 18th infantry, commanding escort, by his exertions when with us, materially promoted our progress, and especially in the crossing of Bear river, at Soda Springs, did the company great service and saved our transportation from destruction.

The weather was fine during the whole trip except two or three days' snow at Soda Springs, May 25th and 26th, and June 7th. It is thought that in regard to snow the Bear River route is decidedly advantageous over any other crossing of the Wahsatch range.

Work was commenced on Weber Bench at Station 391+50 of Reed's line of 1864, about 7½ miles westward of the mouth of Weber cañon, and ended at Station 1781+06 of same survey, near the confluence of Yellow creek with Bear river, in distance being 1,325,308 feet, or $251\frac{5}{1000}$ miles. Of secondary lines during same period, 46½ miles were run, making a total of 297½ miles. Survey completed 28th of June.

Data.—From Weber Bench via Bear River line to mouth of Yellow creek, 251 miles; by Reed's line via Echo, 73 miles.

LINES OVER THE EASTERN RIM OF THE GREAT BASIN—BEAR RIVER TO HAM'S FORK.

After completing the Bear River line the party proceeded to Fort Bridger for repairs and subsistence. On the 10th of July they left this post for the purpose of determining the routes eastward from Bear river to the drainage of Green river.

After thorough exploration, the line was started at Station 10,508, Bear River line; run 8 miles southward to the waters of a small creek; thence up its course nearly due east for 22 miles to the summit or rim of the Great Basin; and thence descending through a rolling country for 3 miles to Ham's Fork.

This experimental line shows the best route from Bear river eastward to be obtained. Its maximum grade is 80 feet per mile, reducible at least to one of 66 feet. The alignment is excellent; work very light and cheap. A tunnel through soft sand rock for 1,500 feet is required at the summit. The summit is the lowest by at least 350 feet of any through the eastern rim.

The reconnoissance of this trip, in connection with those of the 15th and 16th of November following, extended over the whole eastern coast of the Great Basin from Reed's line northward to beyond Smith's Fork. Between Smith's and Thomas's Fork, a range of mountains extends, shutting off any eastern communication to the northward of the mouth of the former stream. Thence southward, except this line of July, there is no route without heavy grades and tunnels at least three-quarters of a mile in length, to the vicinity of Reed's line.

Profile No. 2 shows a comparison between these crossings of the rim.

LINE OF 1864.

Elevation of ground, 7,567; elevation of grade, 7,548.

Grades.—Ascending easterly, equivalent to 5 miles of 80 feet per mile; descending easterly, 3 miles of 116 feet per mile.

LINE OF 1867.

Elevation of ground, 7,209; elevation of grade, 7,093.

Grades.—Ascending easterly, equivalent to 5½ miles of 66 feet per mile; descending easterly, maximum grade 40 feet per mile.

The extension of this line eastward 39.6 miles, down Ham's Fork to its junction with Black's Fork, was reconnoitred November 26th, 27th and 28th following.

Ham's Fork rises in a high country and flows nearly south for 40 or 50 miles. The last ten miles of this distance the river is shut in by high hills into a cañon. The Bear River and Ham's Fork line enters this cañon about midway, and thence for seven miles thereafter location would make occasional crossings of the stream, and be attended by considerable expense. The stream itself is from 30 to 40 feet wide, by 1 or 2 deep, over a bed of small stones, fordable in many places and abounding in trout at its head-waters. At the mouth of this cañon it makes a bend to the eastward, whence for 34 miles an excellent line in every respect can be obtained. For this distance the bottom lands average a mile or more in width, offering extensive fields for cultivation.

The stream itself makes an average fall of 16½ feet per mile. Its valley is shut in between high bluffs the greater portion of the way.

NATURAL RESOURCES.

Timber.—Pine abounds in large quantities near the head-waters of Ham's Fork, down which stream it can be run in June for 75 miles, to the mouth.

Coal.—Extensive coal deposits exist along the rim of the Great Basin, from Mr. Reed's line northward, for over 70 miles. A vein three miles in length was traced near this line of July, and three men of the party were engaged one afternoon in developing it. At this point the vein was at least ten feet wide.

Petroleum.—Petroleum springs are indicated in several localities along the same district.

Iron.—Nodules of iron ore were obtained from several places in the same vicinity.

Gypsum.—Veins of gypsum are frequently encountered.

Specimens of all these resources have been furnished to Mr. Van Lennep, geologist for the company, and pronounced by him to be among the finest collected along the lines of the road. His report of 1867 is referred to for further details.

TABLE OF GRADES.

Ascent.	Level distances in miles, 4.62.	Descent.
Miles.		*Miles.*
7.81	From level to 20 feet per mile	0.60
12.47	From 20 feet to 40 feet per mile	2.00
0.32	47 feet feet per mile	.....
2.00	66 feet per mile	.....
0.76	75 feet per mile	.....
1.82	79 feet per mile	0.60

ALTITUDES.

Bear River valley, at Station 0	6,255
Rim of basin, at Station 1,567	7,209
Elevation of grade, at Station 1,567	7,093
Ham's Fork, at Station 1,742	6,960
Ham's Fork, at confluence of Black's Fork	6,290

This work was completed on the 31st of July. The main line was 33 miles in length, and together with 20.4 miles of secondary lines made a total of 53.4 miles. On the 1st of August the party returned to Fort Bridger. From thence the main portion was ordered to Salt Lake City.

During the first two weeks in August the time was employed in preparing profiles and maps for your inspection. On the 12th of that month I reported to you in person at Green river, and accompanied your party over the route to Salt Lake City. On arriving there the party was immediately reorganized, preparatory to compliance with the following instructions:

CHIEF ENGINEER'S OFFICE, *Salt Lake City, August* 30, 1867.

DEAR SIR: [Paragraph 1.] You will proceed immediately with your party to the Narrows and commence location there at station 1,000. Commence locating by swinging tangent so as to avoid heavy work at 1,016. Cross point at 1,040 through low gap, and curve so as to avoid as much as practicable point at 1,060. All the points will have to be cut some. Strike heavier into point at 1,085, and increase tunnel, if necessary, to 500 feet. Keep on the south side of the river all the way up to the head of the Narrows, connecting with Reed's line on the south side of the river, opposite Solomon Rogers's. The average fall from the head of the Narrows to the foot is 35 feet per mile. No grade above 50 feet will be required on location, and that for only a short distance. Perhaps the line can all be reduced to 40 feet.

[Paragraph 2.] From here commence location near the head of Echo, at the foot of summit grade. Try 90-feet grade from foot of tunnel, hanging to the best slope, or perhaps part on one side of the valley and part on the other; instrumental examinations of the country will determine this. Also try 90-feet grade, throwing one tunnel and cutting the summit 50

or 60 feet; and also 116 feet, cutting the summit 50 or 60 feet. What we desire is to get down with 90-feet grade and not encounter costlier work than tunnel makes. By shaft curvature—say 6°—it is probable we can avoid tunnel, and not have the line cost more than tunnel does; but if 90-feet grade from foot of tunnel gives the least work we will adopt it, as heavy work may impede us, on account of snow. In short, curvature grades should be flattened .05 foot per station for every degree over 3° curve.

LOST CREEK.

[Paragraph 3.] Run a preliminary line up Lost creek, connecting with Bates's line; then run a line up the branch further north, and endeavor to get into Bear river with 80 or 90 feet grade. Avoid tunnel, or shorten it. It is thought that a line can be got through this country, but Mr Bates examined it and decided against it, though he thought a further examination should be made.

[Paragraph 4.] After finishing this, commence on Reed's line, in Bear river, and run a preliminary over the rim of the basin north of Aspen Hill, and endeavor to cut through into some of the ravines leading into Pioneer Hollow or Muddy.

[Paragraph 5.] Also reconnoitre fully the head of the Little Muddy for an opening north and south of Medicine Butte.

GREEN RIVER.

[Paragraph 6.] Locate line from Black's Fork to station 13,700, Bitter creek line of 1864. In ascending from Black's Fork try 60 feet grade to summit. If it makes too heavy work, run down from the summit a short distance on 80 feet, and then run down the valley on 60 feet. In descending into Green river try 62-feet grade, continually descending to the level at crags, or all the way to Green river. If this fails, try 80 feet, until it strikes a grade you can run down with level and 60 feet, crossing Green river opposite station 1,100. Locate up Bitter creek and avoid heavy work as much as possible, as shown on Evans's profile. What is wanted is to overcome this summit with lighter grades and materially reduce the work. Crossing the river where you do, you will throw out the heaviest work on the line, both east and west of the river.

[Paragraph 7.] From Hodges's pass, on the rim, run line down Ham's Fork and connect with Reed's line on Black's Fork.

[Paragraph 8.] As fast as line is run send map of line, on scale of 2,500 feet to the inch, and level notes, that profile can be made from them. Give grade changes where line is run to grade. Send to me at Omaha. The maps want to be made of every separate line, as soon as run. Also give, when practicable, old lines as compared to new on the same map. All reconnoissances should be fully reported, and, when possible, dotted on the maps. Notes of lines cannot be taken too full for our benefit, as we are dependent entirely upon them.

[Paragraph 9.] Fuller notes have been made by me on maps and profiles as I came through the country, which you can make use of. The instructions are given as my idea of the line. Upon examination I may be found at fault. I do not intend them as absolute guides, but want the best line, and such changes in the old line as the country affords. Always, in ascending or descending summits, avoid undulations of grades. Run continually ascending, descending, or level grades. This holds good in all valley lines. Undulations are admissible only when crossing ridges that cannot be turned, or, at some difficult point, to throw out heavy work that cannot otherwise be avoided.

I am, respectfully,

G. M. DODGE, *Chief Engineer.*

F. S. HODGES,
Assistant Engineer Union Pacific Railroad.

The party left Salt Lake the 10th of September, in accordance with the above instructions, which contemplated a revision of Mr. Reed's line of 1864 at its salient points. That portion embodied in paragraph 1 was furnished on the 29th of September, and report, map, and profiles forwarded as per communication dated November 17, 1867.

CAMP 108, BEAR RIVER STATION,
November 17, 1867.

SIR: The location of Weber Narrows being finished, and the maps and profiles forwarded, I have the honor to submit the following report:

[Paragraph 1 of instructions.] You will proceed immediately with your party to the Narrows, and commence location there at station 1,000. Commence locating by swinging back tangent so as to avoid heavy work at 1,016. Cross point at 1,040 through low gap, and curve so as to avoid as much as practicable point at 1,060. All the points will have to be cut some. Strike heavier into point at 1,085, and increase tunnel, if necessary, to 500 feet. Keep on the south side of the river all the way up to the head of the Narrows, connecting with Reed's line on the south side of the river opposite Solomon Rogers's. The average fall from the head of the Narrows to the foot is 35 feet per mile. No grade above 50 feet will be required on the location, and that for only a short distance. Perhaps the line can all be reduced to 40 feet.

A reference to the map and profile herewith forwarded will prove explicit, and show that the instructions have been fully complied with.

To continue on the south side of the river will necessitate sharp curvatures—ten degrees. Should this curvature be adopted, the line can be laid so as to avoid two crossings of the river, and both tunnels, and avoid the subjection of the line as now laid to destruction from snow slides by crossing the river above the exposed points.

The grades are necessarily high to avoid high water, the marks of which are everywhere prevalent. No grade reaching 40 feet per mile has been used, except in one instance of 2,000 feet, where 42.25 has been laid; but this can be lessened if desirable.

By use of six degree curves the tunnel at station 44 of location (Reed's 1,040) can be avoided if desired.

A location has been indicated on the map which, it is believed, will subject the road-bed to as little danger, and be as free from objection of grades and curvatures, as the nature of this cañon affords.

The line is 7 28 miles in length, or 1,114 feet longer than the preliminary.

Most respectfully submitted.

E. S. HODGES, *Assistant Engineer.*

General G. M. DODGE,
Chief Engineer Union Pacific Railroad.

The Weber Narrows is a cañon of the Weber requiring expensive work, in black lime-rock, loose rock, and gravel. The indicated location has two tunnels, aggregating 700 feet, crosses the river (requiring 250 feet truss bridge) seven times, and has 38 per cent. of curvature in a distance of seven miles.

LOST CREEK LINE.

The instructions in paragraph 3 were next complied with.

The following note was found upon map No. 8, of Reed's line, 1864:

See if line cannot be started east of this summit, (head of Echo,) and worked over to the head of Lost creek. Follow Lost creek down to Weber. On tracing, see dotted line of Mr. Reed's reconnoissauce; but did not run line; think it should be thoroughly examined. Try it, and exhaust the question before giving it up.

This Lost creek line was an attempt to obtain a better than the Echo line from Weber to Bear river. It was commenced on the 29th of September. For nine miles the valley is quite open, and the line good. The remainder of the distance to the summit was impracticable for the passage of the wagons, which

had to be sent around to Echo, while the camp was moved by pack animals, and during which snow-storms occurred.

Thirteen miles up from its mouth is the confluence of the two main forks of Lost creek. A line was run up each fork, and through the two lowest passes of each. By one fork an intersection with Bates's line of 1867 was made, by which a connection with Reed's line, on Yellow creek, exists. By the other fork the line was extended by projection to station 12,063 of Bear river line.

The survey proves beyond question the superiority of the Echo line. Via Middle pass of Lost creek a line could be constructed to Bear river without a tunnel, but would require miles of maximum grade, 116 feet per mile, and the most expensive work ascending easterly. These routes are all considered impracticable. The whole vicinity was thoroughly explored, developing no others.

TABLE OF ALTITUDES.

	Elevation above tide water.
	Feet.
Summit of Chalk creek	7,834
Summit of Echo creek	6,880
Summit of South pass, Lost creek	7,240
Summit of Bates's line	7,103
Summit of Middle pass	6,986
Summit of North pass	7,148
Mouth of Lost creek	5,300
Bear river, at end of line	6,330

These lines were finished on the 16th of October. Number of miles run, 56.

DATA.

	Miles.
Mouth of Lost creek to Bear river line	40.35
Mouth of Lost creek to Yellow creek	31
Station 0 to Bates's line	19.72
Length of Bates's line	11
Mouth of Lost creek via Lost creek, La Baume creek, Bear river and Ham's Fork, to Black's Fork	127
Mouth of Lost creek via Weber, Echo, Yellow, Sulphur, and Muddy, to Black's Fork	117.5

Map, scale one-half mile to the inch, and profiles accompanying.

SUMMIT OF WAHSATCH RANGE.

On the 12th, 13th, and 14th of October a reconnoissance with pack animals was made, following the very crest of the Wahsatch through fine groves of pine and quaking asp, without developing a practicable route. It extended to waters flowing into Cache valley. At this point a *marked* depression exists—Bear valley and Cache valley. It is referred to near the close of this report, and demands further exploration.

HEAD OF ECHO, (vide paragraph two of instructions.)

This locality has been the subject of much investigation, having been considered the worst feature along the line of the Union Pacific railroad. Reed's profile of 1864 had shown three miles of maximum grade, with 4,000 feet tunnel, and the rest of a mile heavy cut. The next year an attempt was made to improve it, and abandoned. The same was the case with the attempt made in the spring of 1865.

The obstacle here met is the sudden sinking into the plain of numerous ravines draining westward into the Weber. Former trials have attempted by keeping along the *south* side of the hill to descend into the main ravine, but many secondary ravines crossed the line, causing too expensive work. After full investigation, and grade stakes having been set on the north side of the hill, it was thought by keeping along the top of the divide to the north the side ravines would be generally avoided or headed off, until one was reached offering access down to the main or Echo ravine or cañon.

In accordance, a preliminary was run in the most favorable locality, with such results that a location was immediately made upon the route. A reference to the map and profile submitted gives evidence of the superiority of this over any other location to be made.

The maximum grade is 90 feet per mile, used continually for nearly seven miles, and the sharpest curve six degrees, or radius of 955 feet. During the whole distance of seven miles the percentage of curvature is 50 per cent. The length of line is 2,000 feet longer than Reed's. Wherever any choice of location offered, a location has been made in all.

The line was finished on the 10th of November, a portion of it in one and a half or two feet of snow.

Preliminary	7	miles
Location, main line	7	"
Location, secondary	$2\frac{1}{3}$	"

RIM OF BASIN.

On the 15th and 16th of November I took a pack trip along the rim of the Great Basin, to follow instructions embodied in paragraph 5. The result is incorporated in this report, (line from Bear river to Ham's Fork.)

On the 18th of November the line as proposed in paragraph 4 was commenced, and completed on the 20th. This line, via Quaking Asp creek, was extended over the rim of the Basin to both Pioneer Hollow and the Little Muddy. By the former, 3,900 feet of tunnel is encountered, and about three miles of 116 feet grade descending easterly. By the latter, 3,300 feet of tunnel, and no grade exceeding 60 feet per mile. The adoption of the latter would connect with Reed's line on the Big Muddy about four miles above Black's Fork.

Mr. Reed's line is considered the best, as it passes the rim without a tunnel, and it is thought that his three miles of 116 feet grade, descending easterly, can be reduced.

Length of lines run, 11.4 miles.
Elevation of ground, 7,737, Muddy pass.
Elevation of ground, 7,757, Pioneer pass.
Elevation of grade, 7,375, Muddy pass.
Elevation of grade, 7,395, Pioneer pass.

HAM'S FORK RECONNOISSANCE, (vide paragraph seven of instructions)

On the 26th, 27th, and 28th of November, alone, on horseback, I made a reconnoissance of Ham's Fork. The result is hereinbefore reported, (Bear river to Ham's Fork line.) Snow-storms occurred during two of these three days.

BLACK'S FORK, GREEN RIVER, AND BITTER CREEK.

On the 30th of November the instructions as embodied in paragraph six of instructions were undertaken. Operations were somewhat retarded by frequent snow-storms for the first five or six days. The line followed Reed's, of 1865, very closely, changed in places to throw out his 116 feet grade for one of 80 feet. Two separate crossings were made of Green river, and the line continued five miles up Bitter creek.

Profiles and maps are herewith submitted for reference. Road bed and bridging will be expensive for the last half of the line. In two localities for short distances the line hangs to limestone crags at 50 feet and at 20 feet elevation.

Green river requires 300 feet truss and 800 feet trestle to pass its flood waters.

Bitter creek is very crooked, and is frequently crossed.

The line was finished on the 8th of December,

Its length being	28	miles.
With secondary lines	2.3	
Total	30.3	

SUMMARY.

Mr. Reed had, in 1864 and 1865, fully explored the country to the southward of his Echo and Muddy line. The work allotted to me for 1867 comprised, first, the exploration of the country to the northward of Reed's line; and next, the revision of its salient and objectionable features.

The result of these labors of 1867 has shown that Mr. Reed's line of 1864 and 1865, via Weber, Echo, Yellow, Sulphur, Big Muddy, and Black's Fork, is far superior to any other from Green river to Salt lake, *unless* an extension of the Ham's Fork line can be made via Bear Lake valley, over the Wahsatch into Cache valley, through the depression before reported. (Summit of Wahsatch.) Inasmuch as such a line, if practicable, would reduce the heavy grades and other objections to one locality, and would shorten the line to a common point on the northeastern shore of Great Salt lake by about 30 miles, it certainly demands investigation. The elevation of such a crossing of the Wahsatch would reach between 7,500 and 8,000 feet—500 to 1,000 feet higher than the head of

Echo. Doubtful about the practicability of this route, I should recommend a reconnoissance with barometrical observations as less expensive and more expeditious than a thorough instrumental survey, from Black's Fork, north of Ham's Fork, to common point, northeast side of lake, via Reed's line, Weber and Echo, 180; via Ham's Fork, and Bear lake and Cache valley, 150; via Ham's Fork and Bear River line, 240.

Lieutenant W. W. Bell, 18th infantry, commanding escort, is entitled to the consideration of the company by exertions to promote the safety and progress of the party when with us.

On the 8th day of December I took the stage at Green river for the east, the party being ordered back to Salt Lake City. Their progress was delayed by the high water in Green river, caused by the gorging of the ice during the cold weather of the 6th and 7th. They arrived in Salt Lake City, after much labor, on the 21st of December, at Camp 124, of season of 1867, where they were discharged, after having been in the field and at work, except two short intermissions, since the 1st of July, 1866. These two intermissions occurred in January and July, 1867, while waiting orders at Great Salt Lake City. To their zeal and discipline, and to the exertions of Messrs. Waugh, LaBaume, Doremus, Camp, and other members, is due the amount of labor performed, as set forth below, subsequent to the first of April, a period of nine mouths:

Number of miles run, preliminary	455.6	
Location	16.4	
		472
Number of miles travelled on horseback during personal reconnoissances		250
While with party of chief engineer, inspecting routes		300
Number of miles travelled by wagons		1,100

Respectfully submitted:

F. S. HODGES,
Assistant Engineer.

Gen. G. M. DODGE,
Chief Engineer Union Pacific Railroad.

Report of James R. Maxwell, Assistant Engineer.

OMAHA, *February* 24, 1868.

DEAR SIR: The following is a brief report of my work during the past season:

I joined the party at the Laramie crossing of the Lodge Pole on July 3, 1867, and from that date until the 15th of July worked on the location of the line between Pine Bluff and Cheyenne. Part of the corps then commenced running the boundaries of the claim and the town of Cheyenne, the remainder assisting Mr. Evans to finish the location of the line to Crow creek, which was completed on the 17th of July, after which date all were engaged on the town.

In accordance with your instructions, I left Cheyenne on July 29th, (having staked out the boundaries of the claim and town, and finished six tiers of blocks

near the centre of the town,) and proceeded west, making such changes in the line on the eastern slope of the Black Hills as were directed by you when going over the ground.

When I arrived at Fort Sanders I was left without an escort, the troops being ordered back to Cheyenne. I applied to General Gibson and telegraphed to General Augur for escort to go west with me, but was unable to get any, and, in compliance with orders from Colonel Seymour, returned to Cheyenne, running a set of levels from the summit of the Black Hills to Crow creek for Mr. Blickensderfer, and then returned to the eastern base of Black Hills; made changes in the located line under direction of Colonel Seymour, until September 4th, when escort was furnished, and pursuant to orders from you started for and arrived at the Medicine Bow, September 14, and commenced a preliminary line to the Platte, crossing the range through a pass about four miles north of Brown's Pass.

When near the Platte I spent several days in exploring the country west and south. I then ran a line through the cañon in West Rattlesnake range to connect west of the Platte with Brown's line. This connection is impracticable, involving either a tunnel through rock of nearly a mile in length, or a series of 12° curves, with heavy side-hill cutting.

I then started a line from a point in the valley about four miles east of the river, ran over a divide, and crossed the Platte a short distance above the mouth of the Medicine Bow, to connect with the line from the west run by Mr. Bates. Then, in compliance with your instructions "to locate on what I thought to be the best line," I commenced locating eastward, with a maximum grade of eight-tenths. The greater part of the line was on a lighter gradient.

There was about three miles of heavy work going down into the valley of the Platte, but with a six-tenths grade. The rest of the work was light. There were two six-degree curves near the western end of the line. The others were light, with long tangents between. I finished the line up to the place where Mr. Evans directed, on November 7, and then moved over on Brown's line to locate on it. I commenced at the summit and ran eastward, and sent the teams in to Sanders for supplies. They returned on the 13th with the intelligence that Mr. Bates was to locate from the summit west, and with orders for the escort to return to headquarters. I pursuaded the captain to stay until we made a connection with the line in the Medicine Bow valley, and then started for Sanders, arriving there on the 18th of November.

I went out again, in obedience to orders from Mr. Evans, but was driven in by bad weather.

My field books, maps, and profiles were left at Sanders, with the understanding that the work was to be shown on the large map made for you at that place.

There were two accidental cases of shooting; the first occurred at Sanders, in September, and the other near the Medicine Bow in November. Messrs. Eddy and Huntingdon were the persons hurt.

I desire to acknowledge the valuable assistance rendered by Messrs. Eddy, Bent, Huntingdon and Collins.

My report has been delayed from the fact that I was called east by the sickness of a near relative, and while there was in too unsettled a condition to write anything.

Respectfully submitted:

JAS. R. MAXWELL,
Assistant Engineer Union Pacific Railroad.

G. M. DODGE, Esq.,
Chief Engineer Union Pacific Railroad.

Report of J. E. House, Division Engineer.

UNION PACIFIC RAILROAD COMPANY,
Engineer's Office, Omaha, Nebraska, May 14, 1868.

SIR: I have the pleasure of submitting the following report, embracing the surveys of Missouri river, the labor performed in the Omaha office, the laying out of towns, the erection of buildings and bridges, and repairing of track on the built portion of road under my charge during the year 1867.

MISSOURI RIVER.

Upon the arrival of the different field parties from the west in December, 1866, those desiring to remain in the employ of the company and not wanting leave of absence were placed under my immediate charge, to make further examinations and soundings of the river, to run different lines of approach from a common point in section 2, township 74, range 44 west of 5th principal meridian, to an intersection with the built portion of the road, in order to determine more satisfactorily the best location for bridging the Missouri river. Parties were placed, accordingly, at the Upper Omaha or Telegraph crossing, Lower Omaha or Train table, and the Child's Mill crossing. Soundings were made in squares of 100 feet for a distance of 1,500 feet on either side of centre line at the several crossings. The entire winter was consumed in the development of this work. Profiles and charts showing the location of lines and depth of soundings were transmitted as the work progressed.

At the Upper Omaha or Telegraph crossing, rock was found on the western side of the river from a point below the present telegraph poles, and extending up the river to the initial point of the road.

By referring to profile and chart of this crossing, you will see that at line "P" the rock underlies the entire bed of the river, and is found very near the surface, and in a horizontal position not averaging more than eight feet below surface of low water. Soundings were carried over the sand-bar to the edge of Willows. Rock was found to dip rapidly towards the east from the eastern edge of the water till the depth of 60 feet was reached, when it again assumed a horizontal position.

The rock at this point was drilled into to the depth of two feet in the winter of 1866, and was found to be solid limestone, similar in compactness and texture to the first ledge found in the artesian well at the Omaha shop ground. I con-

sider it to be a continuation of the same ledge that underlies the shop grounds, and is found 20 feet below the surface. This ledge of rock, as demonstrated by the sinking of said well, was found to be eight feet thick. I see no reason why it is not sufficiently compact and well founded to withstand any given weight that might be placed upon it, as contemplated in the bridge plans.

LOWER OMAHA CROSSING.

More labor was performed here than at any other point of the river, owing to the greater width and depth of soundings. By referring to profile and chart you will see that the river is 2,000 feet wide; also, that soundings show an average depth of 60 feet before rock is reached. The dip is towards the east, as at the above crossing. The advantage that this point has over the one above is, that the high table on the western side is reached much sooner; that it requires less miles of new track to make a connection with the built portion of road; also, that the present season has demonstrated that the entire river at its highest flood can be spanned within one mile, while at other points it varies from two to six miles.

CHILD'S MILL CROSSING

Is six miles south of the depot grounds in Omaha. A line from the transfer grounds above mentioned, and crossing the river at this point, intersects our present road at station 375, in Mud Creek valley. The river is very narrow, and rock is found the entire distance across, being 14 feet below the surface of the ground at the western abutment, and 76 at the eastern. The character of the soil that underlies the bed of river is the same at all the crossings, and is composed of fine quicksand, liable to be washed out to great depths by undercurrents.

In examinations of the river made the last two seasons, I have never found a greater depth than 28 feet of water, and this in but one or two instances.

Water soundings have been taken from Rockport to the mouth of the Platte, and they show the average depth of water in the channel to be about six feet. Lines have been run over the several crossings to an intersection with the road as built, and maps and profiles have been submitted.

OMAHA OFFICE.

Two draughtsmen, besides assistants, have been employed making maps and profiles of the different surveys, plans for buildings and bridges, maps of towns, &c. All notes of location, including all outside lines, were sent to this office for compilation, and have, necessarily, of themselves consumed considerable time.

Copies of all maps and profiles have been furnished to Mr. S. B. Reed, engineer in charge of construction; copies transmitted to the New York office; copies furnished to commissioners at each examination of the road; besides a general map of Oregon and the Territories, to accompany report of branch line to Oregon and Puget's sound, is a portion of the labor done in this office.

TOWNS

Have been laid out and claims established, consisting of 320 acres and upwards, at the following stations, viz: O'Fallon's, Alkali, Ogallala, Big Spring, Julesburg, Lodge Pole, Sidney, Potter, Antelope, Pine Bluffs, Hillsdale, and Cheyenne.

Lots have been sold in but two of the above towns—Julesburg and Cheyenne. While Julesburg was the terminus of road, property to the amount of $6,250 was sold, and the amount collected. Many lots were occupied for which no money was received, owing to the inadequacy of law to force collection. The town is now abandoned, there being but one or two places open for business outside of the station.

The town of Cheyenne was located and surveyed in the month of July, and property offered for sale. Speculation ran high for a time. Lots eligibly situated sold, second-hand, at almost fabulous prices. The original or first price of the company was considered very high, being from $250 to $600, but there are instances where lots have been sold for $3,500 by other parties. The company have realized, at the close of the year, nearly $60,000 as first payments. The majority of the lots were sold on two years' time, purchaser paying one-third of purchase money; consequently there must be due on those sales alone $110,000. The town as laid out occupies four sections of land, and the reservation is four miles square.

BUILDINGS.

Plans for coal sheds 25 by 100 were prepared, and buildings erected at the following stations: Grand Island, Kearney, Plum Creek, North Platte, Ogallala, Julesburg, Sidney, Antelope, and Hillsdale, capable of containing 9,000 bushels, substantially built of pine, and supported on good stone foundations.

IMPROVEMENTS OF TRACK.

Trestle bridge, 500 feet long, was added at the crossing of the Elkhorn and foot of grade; also, a large number of smaller ones on the first 300 miles of road. Two 100-feet spans of Howe truss have been added to Loup Fork bridge, substantially built upon stone abutments and piers, with pile foundations. Track was raised at various points, as necessity required, from one to three feet. The largest amounts added to banks were 8,000 cubic yards at Elkhorn river, 18,000 cubic yards at Shell creek, and 21,000 cubic yards at Loup Fork.

In addition to my other duties, there has devolved upon me the furnishing and sending of supplies to the parties in the field, the disbursements of all moneys, the collection of all town lot sales, &c.

Thus have I, in a brief way, endeavored to show the many duties performed during the past year, having but little ground to base a report upon unless going into minute details, which would soon become tedious and uninteresting; and I beg leave to be excused from reporting further.

To H. Lambach and William Cleburne, draughtsmen, I am particularly indebted for valuable assistance rendered in their respective employments.

I am, respectfully, your obedient servant,

J. E. HOUSE, *Division Engineer.*

Gen. G. M. DODGE, *Chief Engineer.*

Geological report for 1867 *on the Lone Tree valley and country west of the Black Hills, on the line of the Union Pacific Railroad Company, by D. Van Lennep.*

OMAHA, *January* 30, 1868.

GENERAL: In submitting to you the report of my geological observations and investigations during last summer and fall, I feel that the distant and necessarily hasty survey I have taken of the country authorizes me to limit the present report to the general geological character of much of the region visited.

I divide this report into three parts. The first part is devoted to the Lone Tree valley, visited by your order to find out what were the indications of coal. The second relates to the country visited in your company from Fort Sanders to Salt lake, mostly along the lines run for the railroad, and back mainly by the old Lander road. The third embraces the region about the lines run by Mr. J. R. Maxwell, near the North Platte, and between it and the Medicine Bow river, and refers principally to its richness in coal.

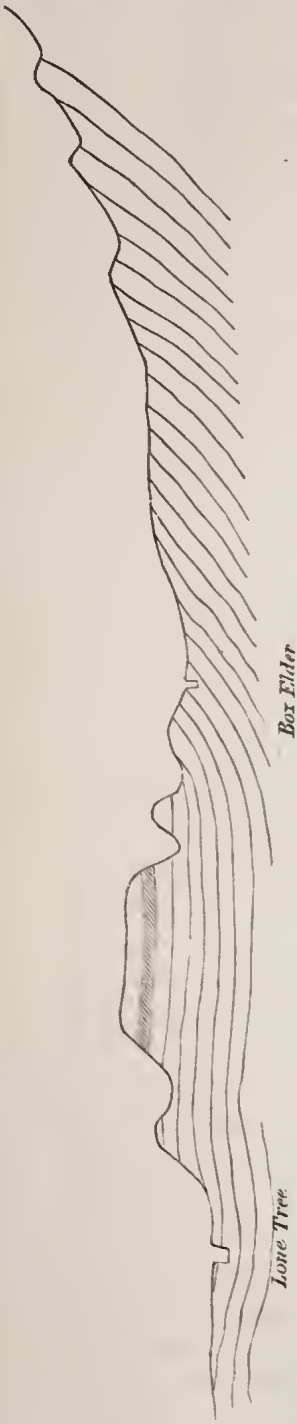
LONE TREE VALLEY.

I left Cheyenne on the 6th of July, with instructions to look for indications of coal, first in the Lone Tree valley, where the Denver line had been run, and then in any place near by; and to be on the 10th of July at La Porte, where the escort I had with me was needed.

I followed the line from Cheyenne to the valley of the Lone Tree. At the point where the line enters the valley, and for several miles down, it is bordered by bluffs showing on their sides sandstones. These rocks are mostly seen on the left, where the bluffs are high, forming an elevated table land. As you proceed further down, these bluffs terminate abruptly on lower bluffs, formed by a lower table land. At about a mile below this point there are, on the east or left side, knolls of sandstone eroded into curious forms, somewhat similar to those taken for granite on the Black Hills. About them, and further east and south, there are three small bluffs covered with hematite, which gives them, at a distance, a dark reddish color. This mineral, in large or small quantities, covers the ground around the place for more than a mile. The bulk is of a fair quality, and some of it quite pure, while some is too much mixed with sand for use. It contains a good deal of manganese.

After this I followed the creek and examined its banks, the bluffs showing no outcrops of rock. Before reaching the crossing of the Laramie road a yellow sandstone is found, in the lower part of which some irregular layers of concrete iron ore are seen, varying in thickness from three to six inches. A gray, crumbling shale is also found, with some of the brown shale which accompanies coal. At a short distance below the crossing is a thin stream of coal, about one-fourth of an inch in thickness, in a bed of brown shale. No further indications are seen at the different points where the outcrops are found for about ten miles lower down the stream. Here the valley spreads into a great, flat country, and the waters of the creek disappear in the sand.

In the hope of finding the strata on the eastern side of this flat country, leaving the main stream, I crossed over to the branch running further east, along the bluffs, and followed its course. On its banks I found the sandstone with iron mentioned above, and the usual shale accompanying the coal; besides this, a perfectly black shale, as well as a seam of impure coal, about one and one-half feet thick. This tributary, after a while, likewise runs into the flat country, so that I continued on a southern course and examined the bluff northeast and east of the forking of the two creeks. On these bluffs sandstone and gray shale outcrop, and the soil coming out of the prairie-dog holes is black and clayish, but nearly opposite station 2,286 of the line, small pieces of coal were found at the mouths of freshly dug holes. I examined again where I thought the bed might come to the surface, but the hill being covered with soil, my search was unfruitful.



For want of water in the valley I had to leave it and take a direct course to the Cache la Poudre, about 10 miles off, and next day I went on to La Porte so as to be there at the appointed time.

As the result of my observations, I conclude that the part of the valley visited is underlaid by some of the formations of the cretaceous or tertiary; which one I could not say, for want of sufficient indications. The beds may be of little thickness.

The strata dip is in some places about 15°, but it is found in different directions, while in the main it is nearly horizontal. From this fact I conclude that the strata have swells coming from the north-northwest, going to the south-southeast, extending in length at a right angle to this line, and giving a cross section to the strata on the first mentioned line, something like the figure opposite, supposing the right side to be the foot-hills adjoining the Rocky mountains, and the left the valley of Lone Tree creek.

The coal beds found on the bluffs between Lone Tree and Box Elder valleys are, so far as I can ascertain by my present knowledge of the country, above that of the valleys, and there exists under these beds a thickness of many feet of sandstone. Thus it is able that the beds will be found above the sandstone seen on the left of the valley, below where the line enters it.

The indications of coal on the prairie-dog holes would authorize the further search of the bed, either down the valley or by digging on the spot.

The quantity of sesquioxide of iron seen in the valley would seem sufficient to keep works of moderate dimensions in good supply. The want of proper fuel is the main obstacle in the way of such an enterprise.

COUNTRY BETWEEN FORT SANDERS AND SALT LAKE.

The main portion of the country under consideration is occupied by rocks of the cretaceous and tertiary periods, forming bluffs, hills, and table lands, which are bordered by ranges of mountains of older rocks: on the east by the Black Hills; on the north by the same and spurs of the same, and the Seminoe mountains; on the north and northwest by the Sweetwater mountains and the Granite Hills, by spurs of the Wind River mountains, and by these mountains themselves; on the west by the Bear River and Wahsatch mountains; on the southwest probably by the Uinta mountains; and on the southeast by the North Park and the Medicine Bow mountains. The southern portion is not bordered by high ranges, and the hills look from where we saw them like table lands, with nearly horizontal strata, cut by deep ravines.

To give a general and comprehensive idea of the thick crust of sedimentary rocks which mainly covers the country, it may be stated that wherever high mountain ranges occur the older rocks project through the stratified crust and carry it up with them on their sides. Hence the younger formations occupy much of the slopes of the ranges, as found in one or two cases under observation.

Taking such a view of the country, we can imagine the time when, having been all submerged, the mountain tops appeared on the surface, at different periods it may be, washed by the billows of the sea. These wore away the younger portions of sedimentary origin on the summits, leaving the harder metamorphic and igneous rocks to appear; at the same time new strata formed on lower grounds yet under water, then gradually the whole country rose, probably by oscillations, to the present lofty height above the sea. But this being gradual, the waters, as they left those high lands to find their level with the receding sea, cut their way through obstructing rocks and strata and formed deep gorges, valleys and ravines which were further washed and deepened by the rains and melted snows of many centuries.

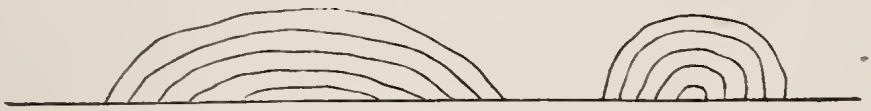
As might be expected from the action of this powerful agency, the country is broken up by wide and narrow valleys, by deep gorges and cañons bordered by precipitous masses of rocks, but of less height, boldness and grandeur on the table lands than on the mountain ranges.

The upheavals of the ranges having much influence in shaping the country and determining its water-courses, the main lines and summits of these upheavals, are, as far as practicable, given with a view to the more clear understanding of the topography. For a better comprehension of this subject it is necessary to bear in mind that the direction of the upheavals in this part of the continent is from southeast to northwest, although the general trend of the Rocky mountain system is from south-southeast to north-northwest. The areas upheaved have usually an oblong figure, the longer diameter placed parallel to the axis of elevation, the spaces between the oblong areas, when the latter are side by side,

being occupied by synclinal strata, with or without subordinate uplifts or foldings.

In the country under consideration, on the southeastern side, are the Parks, which I infer are the product of a great upheaval having a prolongation in the Medicine Bow mountains, with a subordinate upheaval along its side, (the Black Hills,) and a valley between the two, (the Laramie plains,) in which the synclinal strata have but little folding. On the rounding corner toward the northeast and north, the strata have encountered a side pressure or resistance which has folded them, forming the Rattlesnake Hills, and further off the Seminoe mountains, the upheaval of the latter being high enough to leave the metamorphic rocks denuded. The dip between Elk mountain (the northwestern end of the Medicine Bow range) and the Seminoe mountains varies from about 30° to nearly a horizontal line, but about 10 miles before reaching the last mentioned mountains, on the North Platte, the dip begins to be greater, and at some places is folded together. It is necessary to notice here that the Granite range occurs northwest of the Seminoe mountains. It holds no connection, that I could see, with the general upheaval. I conjectured, having passed on one side of it, that it might be an older upheaval not affected by more recent disturbances, offering in that way a point of resistance between it and Elk mountain, which occasioned the folding of the Seminoe mountains and Rattlesnake Hills.

The Granite range is a cluster of hills of granite of the shape of the Hog's Back, irregularly placed, apparently, around a centre, and rising abruptly out of a flat country, probably of drift or alluvial soil, and bare of other rocks. The granite is in layers conforming to the shape of the arch. Sections through the long and short axes would resemble the following figures:



On the northwest, more to the west than the Granite range, are the Wind River mountains, extending on a northwest and southeast line to the Medicine Bow mountains. Between them, on the same line, is another small upheaval, whose granitic summit projects near and northwest of Rawlins's spring; the highest peak is named Duff's Peak. The Rattlesnake Hills east of this place take a northward course, and are formed by this upheaval. Thus these hills, starting on the east at the foot of Elk mountain, run around its base to its northwestern side, then joining the hills of the same range formed by the upheaval of Duff's Peak, extend northward and unite with the Seminoe mountains.

West of Rawlins's spring the strata have a slight dip toward the southwest, and gradually take a horizontal line; then, before reaching the eastern summit on Evans's trail, a small dip to the northeastward, and continue with the same to Salt Well station, on the stage road, about 50 miles southwest of the summit. From this point the dip is to the southwestward; but, about 10 miles further west, it is again nearly horizontal. At the crossing of Green river the strata have very little dip. From Green river to the valley of the Little Muddy, several miles beyond Fort Bridger, the country is occupied by high table lands,

leaving very little dip of strata. This is probably the neutral ground between the disturbance occasioned by the upheavals of the ranges already mentioned and that of the Wahsatch mountains, lying west of it.

North of Fort Bridger, on the road to Montana, near the crossing of the Big Muddy, occurs the summit of an upheaval which has tilted the coal formations about 20° to the northwest. This must pertain to the Bear River Mountain system.

Of the upheaval of the Wahsatch mountains and its effect on the strata of the country around them I am not able to speak, the subject requiring more study than I was able to give on the spot. I will, therefore, only indicate the places where the dip of the strata changes direction.

From the table lands of Fort Bridger you descend into the valley of the Muddy, running through upheavals of strata of the cretaceous formation, that form an arch near the rim of Salt Lake basin, which lies between the waters of the Muddy and Bear rivers. It is under this fold, in a small ravine about four miles northwest of Pioneer's Hollow, that an oil spring occurs, worked by Judge Carter, of Fort Bridger. Beyond this point to Bear river the dip continues to the southwest, and after crossing the river is very small, gradually becoming northeasterly. About eight miles west of Bear river (at the Needles) it rises very suddenly in an opposite dip of about 70°. This is another top of a fold, or perhaps a slip. The underlying rock is a coarse conglomerate. The dip on the southwestern side of this rise diminishes less suddenly, showing an angle of about 30° on the hills south of Cache cave, near the head of the Echo, but lower down, where Reed's line turns northeast, the inclination in the same direction is only about 4° to 5°. About two miles below this there is again a sudden dip of about 20° northeastward, and several miles below a fold of limestone appears on the side of the mountains and above it; but lower down stream a coarse, red conglomerate, having a slight dip southeastward, extends to the end of Echo cañon.

On the Weber, at the mouth of the first cañon, the conglomerate is seen, having a dip of about 60° northeastward; but, at the mouth of Lost creek, a few miles below, it has increased about 60°. Beyond the cañon is an open valley, in which you find the red sandstone with a southeastward dip; and further down hard shale and black limestone occur, with a contrary dip. The range through which the river cañons beyond the last-mentioned valley has a north-northwestern trend, and rocks seen on it seem to flank its sides. The red formation reaches about two-thirds of the way up the slopes, while the top is occupied by bold rocks, with a few trees and bushes scattered over them.

It will be seen from what precedes that the upheavals of the mountains have displaced more or less of the strata covering the country. There is, however, much ground occupied by strata nearly horizontal that would be called table land. The high lands of this nature are found on the summit to a limited extent, but spread over a great part of the Green River valley. They lie northwestward and south of Bitter creek towards Green river, and beyond. They also extend from the base of the Uinta mountains north to and beyond Black's

Fork, and westward to the Muddy valley. They also occupy, on the north, the main valley of Green river, with Marsh's Creek and New Fork valleys, extending towards the Wind River mountains.

BASINS AND VALLEYS.

The country under consideration is occupied by three great basins:

First. The basin between the Medicine Bow mountains, the Black Hills, the Seminoe and Sweetwater mountains, and the summit.

Second. The Green River basin.

Third. The Salt Lake basin.

Before mentioning the valleys occupying these basins, it is advisable to make a few remarks on the manner in which valleys frequently cut their way through strata.

One might infer that the valleys would naturally follow the depressions occasioned by the uplifted rocks. But this is found not to be the case. It is true that the highest ranges of mountains shape the character of the country and its principal basins; but, owing to minor upheavals, valleys, in many instances, deviate from what would be thought their natural course. To illustrate this, some common examples are given of valleys formed in rocks. One of these is where a valley runs in the middle part or top of a fold of rocks, as in the following figure:

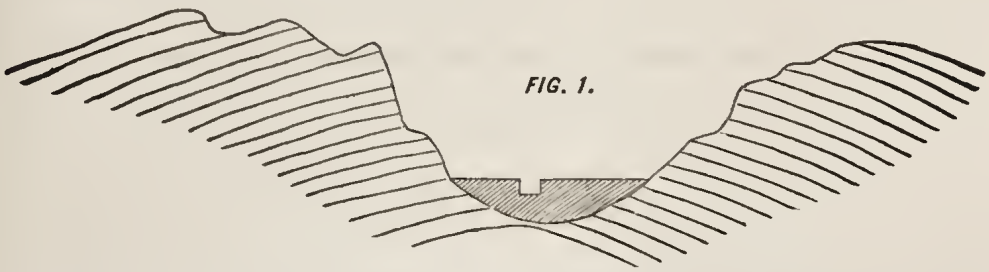


FIG. 1.

Again it cuts the strata obliquely, and sometimes at right angles, across the fold, having minor valleys running parallel with the strike of the rock along the layers, as is represented in figures 2 and 3.

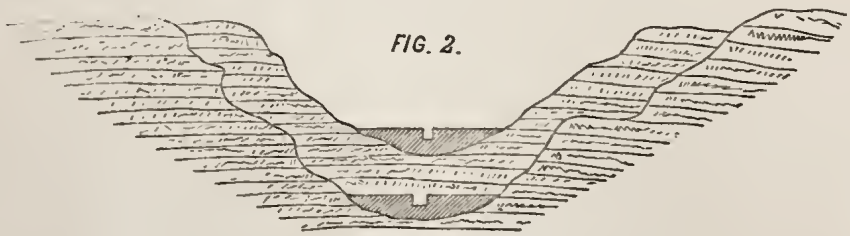


FIG. 2.

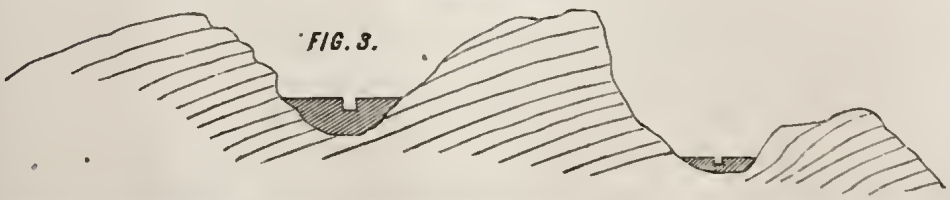


FIG. 3.

The sketch of the North Platte at the crossing of Browne's line, and also that of the North Platte cañon, through the Seminoe mountains, shows some such

instances. It is very seldom that a stream will follow the bottom of a synclinal trough, and if it does it is only for a short distance.

From these facts it may be inferred that the summits of folds by slow elevation come out of the waters and are washed off on top; the water finding easy access to the layers, disintegrates the rocks and works its way down as the country is subsequently raised higher; or this effect may be produced by subsequent atmospheric erosion.

Basin between the Medicine Bow mountains, the Black Hills, the Seminoe mountains, and the summit of the continent.

The water-courses occupying the country from Fort Sanders to the North Platte radiate from the great upheaval south of it—the North Park and the Medicine Bow mountains—and take various shapes, according to the obstructions presented to their flow north by the Black Hills and the Seminoe mountains.

Fort Sanders is in the valley of the Big Laramie, which has a northerly direction, joins the Little Laramie (having its valley further west) and cañons through the Black Hills. After crossing the valleys of the Laramies, as you travel further west you come to the valleys of Cooper's and Dutton's creeks, both running in a northerly direction among the table lands; but, being small bodies of water, and obstructed in their course by bluffs, they form alkaline lakes a few miles north of the line. Further west you meet Rock creek, also flowing north among the table lands; but, meeting the slopes of the Black Hills, it turns west into a valley along these slopes, and a few miles beyond empties into the Medicine Bow river. This stream takes its rise mainly at the eastern side of Elk mountain, and cutting through the strata of the Rattlesnake Hills, flows first in a northeasterly, then in a northerly direction, to the rising of the hills between the Black Hills and the Seminoe mountains, and then turning abruptly to the west (at the mouth of Rock creek) takes its course along the foot of the hills and cuts diagonally across the strata, having high table lands on its left side, and empties into the North Platte about 10 miles below where the latter cañons through the Seminoe mountains. South of the Medicine Bow river the Platte has minor tributaries, of which Pass creek and its branch, Mary's creek, taking their rise among the Rattlesnake Hills, run towards the Platte in a northwesterly and westerly direction, cutting, in their passage through the hills, tortuous cañons.

The North Platte has its source in the North Park, flows northward, cañons through the upheavals of the Rattlesnake Hills several times, leaving wide valleys between the cañons, with moderately high hills along its course, and on reaching the Seminoe mountains its great body of water forces its way through them, leaving a bold and narrow cañon.

The ground between the North Platte and the summit is raised at Duff's Peak, having a small descent between it and the summit, and another between that and the North Platte. The line of hills formed by this rise runs northwest, and is joined by the hills coming eastward from the Sweetwater mountains. Those extend, after meeting, towards the hills adjoining the Wind River

mountains on their southeastern side. On the southern side of Duff's Peak are table lands. The waters on the eastern side of the upheaval have formed a wide valley on the northwest, along the western slopes of that portion of the Rattlesnake Hills which has a northerly direction. This valley has two openings through the hills into the North Platte valley. It extends north to a range of hills and table lands formed at the junction of the Rattlesnake with the Seminoe mountains. On its southern end it opens into another valley, whose waters take their rise on the southern side of Duff's Peak, also at Rawlins's spring, and along the southern highlands. It runs eastward towards the North Platte, and has an opening in that valley. Along it runs Browne's line, towards the summit. The waters of the first valley at present form small muddy and alkaline lakes. Those of the second, though more abundant, seem to sink into the ground.

The streams on the western side of this rise, that is, those of the intermediate eastern slope of the summit, have found outlets through the north, forming the cañons through the hills and high table lands extending west of the Seminoe and Sweetwater ranges. At present most of them terminate in muddy ponds or sink into the ground.

Thus, from the Black Hills on the east to the summit on the west, and from the Medicine Bow mountains and North Park on the south to the Seminoe and Sweetwater mountains on the north, there is a great basin, divided at present in two places; first, by the high table lands between the Laramies and Rock creek; and, second, by the rise of Duff's Peak, between the summit and the North Platte. At the same time smaller basins, which have now no outlets, exist—one between the Laramie and Rock creek, that is, Cooper's and Dutton's creeks and lakes; another between the North Platte and Duff's Peak; while the waters of the eastern slope of the summit run in the Sweetwater valley.

GREEN RIVER BASIN.

This is divided into two parts: one, the valley of Green river and its tributaries; the other, the Red desert. This latter was evidently a part of the former before the country came to its present dry state, and probably formed at that time a shallow lake, whose waters evaporated faster than the high and limited surrounding country could furnish a fresh supply.

Red desert.—The uplift which has occasioned the rise of the eastern summit on Evans's trail has its axis about 50 miles southwest of it, on Bitter creek, near Salt Well station, as mentioned above. Before reaching the eastern summit the waters have formed bottoms with dry valleys and muddy lakes, leaving a high table land west of them forming the summit. This table land extends on the southeast towards Bridger's pass

and presents abrupt bluffs, projecting at various distances towards the west, while on the northwest they are more rounded. In this last direction, on the western side of the table land, a large flat or basin is formed, extending 50 miles towards South pass. It has in some places a great width, say 25 miles, and is limited on the west by high broken ground, composed towards the northwestern end of shales and clays in a state of decomposition, but towards the southeastern end more of sandstone, having some prominent points along its lines

A sketch taken from Evans's trail, west of the basin, shows the abrupt bluffs on the southeastern side, with Black Butte, in the Bitter Creek valley, on the right. Another from the north side of the basin, and east of South pass, shows some portions of the western summit. A section on the southwestern line, from the summit to the axis mentioned above on Bitter creek, could be represented by the accompanying figure. This shows how the top of the fold is on Bitter creek, while the erosion of the strata has formed the Red desert between Bitter creek and the summit. (See preceding page.)

This basin has, as far as ascertained, no outlet, but its waters form several alkaline lakes. On Evans's trail, in the month of August, when it was traversed, its bottom was soft, sinking under the weight of the horses and wagons, though dried up. It is composed of bad soil from the decomposition of shale and calcareous clays; is of a deep red color, showing the presence of anhydrous sesquioxide of iron, which is of common occurrence in the shales and clays of the surrounding country, and the result of high internal heat. This color, and the want of drinkable water, have obtained for it its present name, Red desert. The southern margin of the basin, at the foot of the bluffs, is mainly formed of fine, loose sand, gathered into mounds by the winds.

Beyond the northwestern end of the basin is South pass, which crosses over the foot-hills of the southeastern end of the Wind River mountains. It has these mountains on the north, and the hills extending west of the Red desert and joining the same mountains on the south; on the east, the head of the Sweetwater; and a few hundred feet west, the head of Little Sandy, a tributary of Green river. Thus the waters of the Pacific and Atlantic are in close proximity at South pass, and equally so at Bridger's pass, southeast of the basin, where the waters of the Muddy take their rise on the western slope, and those of Sage creek on the eastern, but between these two points lies the Red desert, which separates, by many miles, the waters of the eastern and western slopes, forming thus two summits on the line of the continent.

Green River valley.—On the southwestern side of the high ground bordering the Red desert, the tributaries of Bitter creek have their source, forming deep cuts in the coal formation, and running in a general southwesterly direction to Bitter creek, which in its turn runs northwestward, then westward a few miles, through the uplifted strata and the more level ones, before emptying into Green river. On the northwest the Pacific spring, and the Big and the Little Sandy, taking their rise, the first along the hills bordering the Red desert, and the last two among the hills on the southeastern end of the Wind River mountains, empty into the Sandy. This river runs in a southerly direction towards Green river, into which it empties. The beds of these streams, as far as seen,

are cut principally through clay formations, where strata are nearly level. They seem unconformable to the rocks of the Wind River mountains, but were probably formed when the mountains had risen to a considerable distance.

On the north of this valley the Wind River mountains have a northwestern trend, thus approaching each other and uniting. It is at this point that the main stream takes its rise, running in a southeasterly, and then in a southerly course. It receives the waters of the Wind River mountains mainly by the New Fork, and on the west by many tributaries, those of the Bear River mountains, Marsh's creek, Piney, Labarge, &c. In its course further south it collects the waters of the hills south of the Bear River mountains, by Harris's Fork and the Muddy; also, the waters of the Uinta mountains, by the Muddy, South Fork, &c.

We have here another basin opening on the south and bordered on the east by the rim of the Red desert and the high lands of the summit; north by the Wind River mountains; a portion of the south by the Uinta mountains, and west by the Bear River and Wahsatch mountains.

The waters of the eastern slope of the Wahsatch mountains do not run into this basin, though part of them must have done so when the valleys were less deeply cut.

SALT LAKE BASIN.

Of the numerous valleys of this great basin I will mention only those visited, describing their courses and noticing their peculiarities. In connection, some of the tributary valleys of Snake river will be referred to.

Bear river, of whose tortuous valley I can speak with but little knowledge, takes its source in the Uinta mountains, forms a valley running north along the base of the Wahsatch mountains, collecting the waters of hills on their eastern side, then passes between these and the Bear River mountains, receiving the waters of hills on both sides, and enters Soda Spring valley; after this, running in a westerly direction, then in a southern course around Cape Horn. It enters, at this point, another valley, crosses to its southern side, then taking an easterly course towards the head of it, forms a long cañon southward through the hills and enters Cache valley on its northwestern corner. Along this valley it runs several miles, then crosses it also, and cañons through a small range which borders Salt lake on the north. Further south it empties into Salt lake, thus collecting the waters of hills on the eastern slope, and all along the northeastern, northern, northwestern, and western sides of the Wahsatch mountains. Some peculiarities of the three valleys which it passes are worth noticing. They are probably some 10 or 12 miles wide, and from 20 to 30 miles long, running from the southeast to the northwest.

Cache valley has a range of hills on its southern side, bordering Salt lake, with strata having a dip towards the lake. On the northern side the highest peaks, looming above the foot-hills, look like a distant, huge blue wall, and as seen from the south the strata are nearly horizontal along the summit, with an opposite dip.

The valley lying south of Soda springs has around it mountains of the same character. They diminish in size towards the northwest, leaving a broader open-

ing valley in that direction with higher ground. Through the hills on the north side, at Cape Horn, where Bear river enters the valley, there is a wide gap opening on the southwestern end of Soda Springs valley. The bottom of the valley has its highest point at about the middle part, and opposite to this gap, with descending ground on all sides towards the hills around it, and is covered by cellular basaltic diorite and lava, while the highest point is capped by two or three knolls. One of these, which I examined, is about 50 feet high, with a hollow about 25 feet deep in its top, partly filled with lava broken from the sides and lying in thin layers, with an outward dip all around the cavity, showing that it is evidently an extinguished crater. Going towards Soda springs you find swells of dioritic rock, whose tops are cracked in their length. In many cases the rock is broken and has fallen in, being hollow underneath. In other places large areas have caved in to the depth of several feet.

This kind of rock, in similar condition, extends along Soda Springs valley. Towards the northwestern end of it the springs are indicated by white and red knolls, formed by deposits of carbonate of lime and sesquioxide of iron, precipitated by the presence of carbonate of soda. These substances are probably held in solution by free carbonic acid, which escapes by exposure to the air. The deposited lime and iron accumulating at the point of egress of a spring form a knoll, and finally rise to such a height that the waters have no longer power to issue out, and the deposit covers it over. The water then usually forces its way through lower ground, and continues its deposits, thus forming numerous knolls. The largest spring I saw was near the margin of Bear river, flowing from under the bank, the current keeping it clear of deposit. I noticed also one spring rising in the bed of the river, the bubbling up of the water indicating the spot. Most of the ground about the springs gives a hollow sound to the tread. About four miles northwest of the springs, near Mr. Hodges's line, he reports having found a bed of sulphur. Some specimens brought with him are nearly pure. No granite or igneous rocks were found on any of the hills around the valleys. Quartzite boulders are numerous, and some are also found in place.

The valley northwest of Soda springs, in which the Blackfoot takes its rise, has in its bottom the same volcanic indications. It opens westward, and has high lands, with one or two knolls similar to the craters south of the river. In going from the Blackfoot to the Lander road, along the head-waters of streams emptying into the river, you find the same swelling of the rocks, with similar cracks, and hills formed by masses of broken trap, showing the existence of a dike of large dimensions.

The strike and dip of the strata, as noticed at several places around these valleys, may indicate that they are upheavals, which have been worn down by the water until their central parts have been cut out into broad valleys, while their sides, having been less subjected to erosion, have remained, forming the ranges around the valleys.

Where the bottoms of the valleys are paved with volcanic rocks, and there are craters on the highlands, it would be natural to suppose that by the deepening of the valley in the centre of the upheaval the earth's crust would present

less resistance; and the melted fluid trying to force its way through would burst out and overflow the surface.

Another supposition would be, that these valleys are large craters of volcanoes which, by cooling, formed the rock surface, while from the knolls in their midst may have come out the last overflow of lava in their intermittent life before being extinguished. The openings towards the northwest might be the outlet of the lava during the eruption.

Again, another admissible supposition is, that they are summits of volcanic mountains which have sunk down to their present position. A better knowledge of the country could probably decide the question.

Echo valley runs in a southeasterly direction to the Weber. It has the eastern rolling foot-hill of the Wahsatch mountains at its head, but going westward as you descend its stream the hills become higher and bolder, showing high, precipitous rocks on the north, aud forming a narrow gorge before reaching the Weber.

The Echo at its mouth meets the Weber flowing northward in a rolling and high mountainous region, but soon the latter stream enters a wide valley, with rolling bluffs on the east and north. At the western end it forms a winding cañon through the mountains several miles in length; extends northward and comes to another wide valley between the mountains, dotted by Mormon farm-houses and fields. The mountains becoming higher as you go westward, the river enters a narrow gorge through a range extending from the south to the northwest, and unites with the Salt Lake valley on its eastern side; it flows to the lake in a west-northwesterly course.

Salt Lake valley is bounded on the east by a high range of mountains trending northward, then north-northwestward. The highest peak is on the southeast side of the valley, being the main upheaval seen in this direction. The rocks on the northern side show very distinctly their lines of stratification running around the upheaval, and they have further north, on the hills around Fort Douglass, a southwestern strike. On the south of the valley and west of this range are low hills through which the river Jordan comes in from Utah lake. Further west a high promontory exteuds into the lake. The islands in the lake, the promontory on the north, and the hills to the west, are a great deal lower, aud barren of vegetation. At present the lake occupies the centre of the valley, and is surrounded by a flat many miles in width—broadest on the southern side; streams of clear water run from the mountains on its eastern and northern sides. There are also several saline and hot sulphur springs coming out at the base of the mountains. The waters of the lake are said to contain 25 per cent. of saline ingredients. This amount may be accounted for by the presence of salt springs; nor is it uulikely that there exist deposits of common salt in this valley, for they are of frequent occurrence further west.

The old craters found north, and the occurrence of ragged, cellular diorite or lava on the slope of one of the hills north of the lake, would indicate that any phenomena met in this valley likely to be produced by volcanic action may be attributed to it in that region. The old settlers say that the lake has risen several feet since their arrival; accounting for this increase by moisture, by the irrigation and cultivation of the valley since its first settlement.

In going from Soda springs across the country to the Lander California road, we entered some of the head valleys of Snake river, and followed the road along the course of a few of these. A brief notice of them is given.

The head of the Blackfoot, northwest of Soda springs, was mentioned above. We skirted on the east, in going further north of this valley, three wide and round valleys, tributaries of the Blackfoot. They are similar to those mentioned above, in having the same lava spread over them. One is covered by a high marsh. After this, before reaching the Lander road, a low ridge was crossed, which rises into high hills toward the east, extends northward, and encircles on those sides Jack Gray's valley. The rocks on the hills south of the valley are limestones, sandstones, and grits, having a west-northwest strike, with an east-southeast dip of 15°; the road traverses the hills east of Jack Gray's valley. These hills are rolling, are then followed by higher ones eastward, with deep ravines thickly covered with pine and hemlock. From these hills you descend into the valley of Smoky creek, which further east cañons through lower hills, enters Pleasant valley, and empties into Salt creek. All the rocks of the hills mentioned above are sedimentary and hardened. Before reaching the cañon several salt springs are encountered on the right of the valley, covering the bottom with a crust of salt. The first one reached is very large, has been cleaned, and a covered reservoir built around it to supply small works started a few months since for the purpose of salt manufacture. Only a small portion of the water is used. The spring is said to contain about 25 per cent. of chloride of sodium, with little impurity. The salt manufactured is supplied to Idaho, Soda springs, &c. The brine is so strong that salmon trout caught in the Smoky are salted and preserved by letting them lie a day or two in the waters of the spring after dressing them.

Pleasant valley is broad, bordered by two lines of hills on the northeast and south, coming in close proximity towards the east at the head of Salt creek, where they join the main range of the Bear River mountains. The creek empties into Snake river. The hills on the sides of the valley show anticlinal strata; they are high and ragged on the north side, but on the south more rolling. The formations are red at the bottom, yellowish in the middle, some of the upper ones having the appearance of limestone; all sedimentary.

From this point the road ascends the Bear River mountains, which are covered with timber, and have within a few miles of each other the waters of Bear river, of Snake river, and Green river. Coming eastward it descends into the valley of the Piney, an thence over rolling hills crosses to Mark creek, both tributaries of Green river.

ROCKS.

Rocks found in place in this region may be classified as usual, viz: igneous, metamorphic, limestone, and sedimentary. The igneous and metamorphic are found mainly on the mountain ranges.

The igneous rocks are trap and cellular basaltic diorites or lavas. Trap is found on the Black Hills, as mentioned in my report of 1866. On the Medicine Bow and Seminoe mountains, which I have not sufficiently explored to be able

to tell, it is most likely to occur. On the granite range I have seen a dike of trap in the granite. Traps are of frequent occurrence along the base of the Wind River mountains. On the Wahsatch and Bear River mountains I did not meet any of these rocks, except on the hills northeast of Salt lake, where some ragged, cellular diorites or lava lies over what appears to be a dark gray limestone, near the foot of the hills; but traps are most likely to occur on these mountains in spots not visited. The same kind of lavas as mentioned above were found in the valleys of Soda springs, and the two adjoining ones, in which there are extinguished craters; also on the hills along the head-waters of the Blackfoot.

The metamorphic rocks, occurring mostly in the middle portion of great upheavals, are granite, gneiss, quartzite, mica schist, sienite, diorites, chloritic gneiss, schist, &c. These rocks occur on the Black Hills, as reported in 1866. Granite and diorite were seen at the northeastern base of Elk mountain; and there can be but little doubt, from the appearance of the Medicine Bow mountains, that most of these rocks occur in them. The back hills, north of the mouth of the North Platte's cañon through the Seminoe mountains, are evidently formed of granite, and probably contain some others of these rocks. The granite range is composed almost entirely of granite, as already described. Along the head-waters of the Sandy and Sweetwater, granite, sienite, and diorites, as well as quartzite boulders, are seen; also a rock of a deep red color, composed of feldspar, specular iron, and some quartz; this last rock occurs also on the Black Hills. Granite probably occupies the summits of the Wind River mountains, which present to the view a bold and ragged appearance; but descending to the Sweetwater mines, the granite shows itself on the highest points, while mica schist, diorites, the specular iron rock, chloritic gneiss, and schist, are met with on the lower hills. Quartz veins with feldspar are very numerous. The veins in which gold has been discovered, in what are called the Sweetwater mines, are mostly in mica schist, which covers a large extent of country extending 10 or 12 miles eastward towards the main Sweetwater valley. About 20 or 25 miles east of the mines some of the other metamorphic rocks are met with, and have here also numerous veins of quartz.

Close to and west of Duff's Peak a hill of granite appears, and some is again seen in a ravine southeast of it, coming out from under a mass of quartzite rock. This latter rock takes more the nature of granite as it comes in contact with it. The quartzite is found in large masses and thick slabs south of this point, near Rawlins's spring. The waters of the western slope of the peak have formed a cañon through it, in which Browne's line runs.

I did not come across any granite in the Wahsatch mountains, but a white albitic granite, of which the Mormon temple is being built, comes from the southeastern side of the mountains bordering Salt Lake valley, where there is a centre of upheaval. The gneiss, sienite, diorites, chloritic gneiss, and schist and quartzite probably abound in the same locality. They were met in the second Weber cañon and along the slope of the mountains bordering Salt lake on the northeast. Quartzite is very abundant in the first Weber cañon, and it has frequently been met with in place on the hills along the course of Bear river, north

of the lake; also on Bear River mountains, but it more frequently occurs in large and small boulders, being rounded into pebbles. The other rocks were not seen in the last-mentioned places.

It is among these rocks that we may look for the veins containing the precious metals. North and south of this region, and recently in the eastern extremity of the Wind River mountains, there have been discoveries such as seem likely to equal any yet made on the range. The gold-bearing veins here found are mostly hard quartz, free from the baser metals. In some cases there is only a coloring of them in the joints of the veins, introduced apparently subsequent to their formation. The gold is usually not seen in the quartz, but in some veins it occurs in clusters, mixed with pieces of quartz, and also spread about in small specks.

Some of the other mountains are known to contain the precious metals. The Medicine Bow mountains were partly explored, I am told, some two years ago, and parties are reported to have found gold and other metals, but the country being a dangerous one to travel in since the Indian hostilities, no further development has been made. Such portions of the Wahsatch mountains as are formed by these rocks are reported also, by persons likely to be well informed, to contain the precious metals in such quantities as to remunerate enterprising men.

Of the nature of the rocks of the Uinta mountains I have no knowledge, nor of those of the Seminoe and Sweetwater mountains, but the appearance of the last two at a distance would seem to indicate that they are mostly formed of sedimentary rocks, or those only partially metamorphosed. The Bear River mountains are also of the same character.

Limestones.—As reported last year, limestone covers a great portion of the western slope of the Black Hills, but going westward on the lines run for the railroad this rock is not met with in any other place before reaching Rawlins's spring. Here, apparently, the limestones of the Black Hills outcrop over the spring, and have a red rock in their vicinity.

There is every reason to believe that these rocks outcrop also on the Seminoe mountains, which have not been explored far enough on their slopes to ascertain the fact. They are found in that portion of the range called the Sweetwater mountains.

East of the Wind River mountains, after passing the metamorphic rocks occupying the foot-hills, you cross on the old Sweetwater California road, about 25 or 30 miles east of the mines, hills formed of these rocks. The limestones met with on the Wahsatch mountains have not the same general physical character with those of the Black Hills. They occur at the head of the Echo valley; again, about midway down, some outcrops are seen which are of a different character, and if the succession of strata has not been very much misunderstood, these lie a good deal below the first. In the first Weber cañon, at the mouth of Lost creek, there is a small thickness of limestone, mostly in layers with clay. Again, a short distance from the end of the cañon is a black limestone, effervescing little with dilute muriatic acid, but in the second cañon none was seen.

On the mountains bordering Salt lake limestone was seen about two miles northwest of the city, lying above the sulphur springs of that vicinity. It is

burned for lime. It effervesces little with dilute muriatic acid, showing that it is impure. It may be dolomitic. On the hills north of Camp Douglass there are many kinds, some effervescing little and others much. Again, on the hills northeast of the lake, a few miles east of Bear river, gray and blackish limestones are found covering the slopes of the mountains. In both the cañons of Bear river limestone is found resembling that seen over the sulphur spring. On the hills which were crossed in going over from the valleys of the head-waters of the Blackfoot to the Lander road, and extending along the south side of Jack Gray's valley, it is found in many places; also in crossing the hills from the last named place to Salt creek. Around Soda springs and in one of the valleys north of the Blackfoot, trevertine is found.

Sedimentary rocks, as referred to in this report, are the conglomerates, various kinds of sandstones, grits, and shales. They are such as have not been metamorphosed by the action of internal heat. They usually form in this country the understratum of the table lands, showing themselves on the sides of the hills of the basins, and also on the foot-hills of the mountains.

In the basin of the North Platte the lower formations of these rocks are found on the slopes of the Black Hills, and along the southern slopes of the Seminoe and Sweetwater mountains, and also form hills extending between these several ranges. They have not been sufficiently explored to give the order of their occurrence. On the hills extending from the Black Hills to the Seminoe mountains, near Medicine Bow River valley, and at a point about 14 miles below the mouth of Rock creek, is found a rock of compact white gypsum. I am told that a similar rock occurs in the vicinity of La Porte. These rocks probably cover also part of the western slope of the mountain.

Overlying the last mentioned rocks is a great thickness of sandstones, whose upper part usually contains seams of shale with small beds of coal. This last mentioned portion, which has been seen and better examined on the North Platte, gives the following succession and thickness, judged by the eye. It is given from the bottom, going upwards:

White silicious sandstone.

Three feet grayish shale.

Fifteen feet whitish sandstone.

Three feet grayish shale.

Fifteen feet whitish sandstone.

Three feet grayish shale.

Fifteen feet whitish sandstone.

Four feet deeply colored brown shale, with about a foot of coal.

Fifteen to twenty feet white sandstone, the joints of which are colored almost black by iron.

Twenty-nine feet black and brown hard shale, with concretionary seams of sesquioxide of iron from 3 to 8 inches thick, at distances from 3 to 6 feet apart.

Five feet hard ferruginous sandstone, gradually becoming white and shaly at bottom.

Twenty feet shale with sulphur, black and hard at top, getting more clayish and softer, then brown and yellow, but again turning black, and changing as before

to the bottom. It has occasionally large shells, (ostrea,) deformed and covered with small crystals of selenite.

Ten to fifteen feet hard gritty sandstone, whose joints are colored yellow-brown by iron, having a seam of 6 to 8 inches of shaly sandstone on top, mixed with pieces of shales, and in the middle another similar seam with the same kind of pieces of shells, (ostrea.)

Most of the Rattlesnake hills are formed by these rocks, having the series given above outcropping here and there. On the North Platte, above and some 10 miles below Browne's line, they are a prominent feature of the country. The series given above is found about 10 miles below the line, and is likely, also, to appear above it. The sketch of the crossing of Browne's line shows some of them. Portions of them are met with a few miles west of the table land dividing Medicine Bow valley and Rock creek. In the valley of the Big Muddy, on the road from Fort Bridger to Montana, the upper portions outcrop. Very near and above the series given there is, on the North Platte, a formation mostly composed of grayish and yellowish sandstone, from 200 to 300 feet thick, overlaid by the following series, calculated rather imperfectly at different places, and connected together. It commences at bottom, going up the strata:

Gray sandstone.

Thirteen feet brown shale, with about $2\frac{3}{4}$ feet of coal.

Five feet sandstone, shaly at first, (about 6 inches,) ferruginous and hard at top.

Twenty feet sandstone with brown shale, and about 10 inches coal with ferruginous sandstone on top.

Fifteen feet black shale with seams of concretions of iron.

Ten feet sandstone, white, laminated at bottom, hard and ferruginous at the upper part.

Fifteen feet black and brown shale, with concretionary seams of iron.

Ten feet brown shale, with about $3\frac{1}{2}$ feet of coal.

Six feet sandstone, ferruginous towards the top.

Six feet reddish and brown shale, with selenite.

Five feet hard and white sandstone.

Several hundred feet of whitish and yellowish sandstone.

A formation coloring the soil deep red, (not examined.)

About 150 feet yellow and brown sandstone.

Formations of ferruginous sandstone, with shales and coal repeated three or four times. In these fresh-water shells are found, *melania* and *vivipara*.

About 50 feet of sandstone.

This section is inserted here more to give an idea of the general character of these coal formations than as a base for guidance. The formation varies in different parts of the country, and the section exposed in one place would hardly be a safe guide in another.

Between Medicine Bow river and the North Platte a part of the first series given extends, by an upheaval of the Rattlesnake Hills, near the summit of Browne's line, towards the north and northeast; while more south it extends west along the northern side of those hills towards the North Platte. The second series is found eastward of the rise mentioned above, extending to the

Medicine Bow river, occupying the high table lands of that section of country, and again northwest of the same rise, at the mouth of Medicine Bow river, covering the high table lands that descend towards the North Platte. In both these regions good coal, in beds from four to eight feet thick, have been found, but in greater quantity in the last portion mentioned, probably by reason of more thorough exploration.

A part also of the second series is found in the Rock Creek valley. Beyond Duff's creek, along the western side of Separation creek, parts of the second series occur, but with some modifications. A good coal bed, whose thickness was not ascertained, and many others of inferior quality, were seen in your company. This series also lines the rugged sides of the valleys of the tributaries of Bitter creek, and is found in the main valley almost as far to the west as Salt Wells station. It also reappears about six miles west of this station. In the first part of the valley mentioned, several outcrops of coal of various thicknesses were noticed. Good coal, of sufficient thickness to be mined, is said to outcrop in different parts of the valleys, and has been used by the station men in many instances.

North of Fort Bridger, on the road to Montana coming from the table lands to the Muddy, some portions of these formations are passed over beyond the crossing of the Big Muddy, on a tributary of Bear river, along which Hodges's line runs. Coming from Harris's Fork they are well represented by outcrops on the rugged hillsides. A bed of good coal, about seven feet thick, was found by Mr. Hodges in this valley. In the upper part of it several small openings were seen charged with sulphuretted hydrogen, probably obtained by filtration through beds of coal or shale containing sulphur. An oil spring is also reported in a side valley on the north.

West of the table lands of Fort Bridger the tertiary formation begins to appear on the surface, and outcrops of coal beds are found further west, near the rim of the Salt Lake basin, extending to Bear river. At Sulphur Springs station there are two beds of coal inclined at a high angle, (about 75°,) about six feet thick, of good coal. In the same small valley, opposite to where the coal is seen, an oil spring comes out. It does not flow, but the oil is gathered from the top of the water and used for lubricating purposes. A few miles north of this place is a larger spring, owned by Judge Carter, of Fort Bridger. This spring overflows at certain periods, and has around it a thick deposit of asphaltum. The oil is thin and of a deep green color. In the strata above the outcrops of the coal beds of this locality, near Pioneer's Hollow, fossil shells, *melania* and *viripara*, were found, proving these deposits to be fresh-water *tertiaries*. Similar shells are found in Bitter creek, near Laclede station.

It will be noticed, from what has been said of the cretaceous and tertiary formations, that they occupy most of the table lands and valleys of the country, and may be located as follows :

The cretaceous occupies the Laramie plains, extending west beyond Rock creek, and outcrops on the western and northern slopes of Elk mountain ; also on the southern hills of the Seminoe mountains. West of the summit of the continent they occupy the eastern hills of the Wahsatch range, and extend

north, the Bear River mountains being probably formed mostly by these formations. It is likely that the western slopes of the Wahsatch, between Salt Lake City and the Weber cañon, will be found to be formed of rocks of this period. Outcrops are again seen between the North Platte and Duff's Peak; also beyond the last mentioned place and Separation creek Some hills between the Wind River mountains and the Granitc range are doubtless of the same period.

The salt-water tertiary outcrops on the Rattlesnake Hills, along the northern base of Elk mountain, and extends north beyond or west of the North Platte. West of the summit I noticed it on the road from Fort Bridger to Montana, as you approach the Big Muddy, and where the road crosses this river. The fresh-water tertiary, with the coal, is found on the northwestern and northern, and southeastern parks of the country, lying between the Medicine Bow river, the North Platte, Elk mountain, and the Seminoe mountains. It is found again west of Duff's Peak, along Separation creek, extending towards the summit. Beyond the summit it is met with in all the valley of Bitter creek. It also occupies the valley of the Little Muddy, at Pioneer Hollow, and extends beyond the rim of Salt Lake basin into Bear River valley, where it is crossed by the stage road, west of Fort Bridger.

The clay formations, which seem to overlie the last, occupy the table lands between the Uinta mountains, Muddy creek, Green river, and the Wahsatch mountains; then, again, the northern portion of the Green River valley, lying between the summit, the Wind River mountains and the Bear River mountains.

The triassic and jurassic are probably found near Duff's Peak, and also on the southern hills bordering the Seminoe mountains, east of the cañon of the North Platte.

The carboniferous period is indicated by metamorphic limestones in the valley of the Weber and in the mountains northeast and east of Salt lake.*

In the valleys and flats surrounded by these rocks, especially where the water-courses are small, and sinks or ponds occur, alkali covers the surface or is mixed with the soil. It would seem that some of the rocks are impregnated with it, and by their decomposition or the filtration of water through them the alkali is dissolved and carried with the spring freshets into places where, by evaporation during the hotter months, it is left on the soil. Small springs, and standing waters of ponds and streams, are frequently saturated with it. One of the greatest deposits seen was in Mary's creek, where the spring freshets make deep holes in the bed of the stream and cover part of the bottom land. The alkali is left behind, encrusting the surface and giving a yellow color to the water filling the holes.

The rocks which seem to overlie the formations already mentioned are seen in the table lands on which Fort Bridger is built. They begin a few miles east of Green river, near the mouth of Bitter creek, and extend west and north to the valley of the Muddy, and southwest towards the Uinta mountains. Church Butte is formed of some of these. They are supposed to be mostly hard,

* I am indebted to Professor J. S. Newberry, of the School of Mines, Columbia College, New York, for the determination of the fossils brought with me.

clayish and marly rocks, but were little investigated. Along Green river, near the mouth of Bitter creek, the rocks are whitish and grayish marls, capped on the highest points by some remains of a red, coarse rock, which has better endured the wear of time, and stands in masses that look like ruined towers. These rocks are also met with in the country between the Little and Big Muddies, northeast of Fort Bridger. Beyond Lone Tree station the surface rock is a greenish marl, and at Church Butte it contains seams of a coarse, dark-greenish-colored sandstone and conglomerate. Further west the rocks, seen from a distance, seem to be of the same nature, but variegated white and light-pinkish in color.

The sedimentary rocks west of Bear river cannot be connected with the preceding ones, for want of more thorough examination of the table lands of Fort Bridger and those west, and for want of fossils. Their nature and locality only will be mentioned.

Shales and sandstones, with limestones mentioned above, are found at the head of Echo valley; further down are red and variegated red, yellow and blueish sandstones, and hardened clays of the same colors; after these occurs a red conglomerate, with round pebbles, usually of quartzite, sometimes six inches in diameter. From some of the high crevices in this rock oozes out a substance similar to asphaltum, but which could not be reached and has not been examined. This conglomerate extends as far as the entrance of the first Weber cañon, and varies from coarse to fine. In the first Weber cañon are sandstones, grits and shales. Between the two cañons are sedimentary rocks, coloring the soil red along the low foot-hills of the range through which the river forms its second cañon.

The hills bordering Salt lake east and north of the city, and extending north to the Weber, are sedimentary; mostly shaly marls, shales and sandstones. Deposits of the same nature occur north of the Weber and most of the way to Bear river on the north side of the lake. Some of them are metamorphosed.

The hills extending along Bear River valley to Soda springs are for the most part of this kind, and the same is true of the Bear River mountains. The highest portion of these mountains was, however, crossed in a snow-storm, and it was difficult to ascertain the nature of some of the peaks. The hills and bluffs of Green River valley to the Wind River mountains are formed of similar rocks, mostly clays and sandstones. In the valley of Marsh's creek some of the rocks forming the table lands on each side greatly resemble the tertiary sandstone east of the Black Hills.

Drifts and terraces.—Drift (local) is usually found in thin or thicker deposits on the table lands surrounded by higher ranges, and on the low hills in the basins mentioned. On the hills between the Big and Little Laramie rivers, it is mostly composed of fine material. On the table lands dividing Rock creek and Medicine Bow river there are pebbles a cubic foot in size, of quartz or quartzite, usually colored dirty yellow outside. The material is less abundant towards the North Platte and the summit. In the Green River valley it is thickest between Bear River and the Wind River mountains. On the hills near the last mentioned range large boulders were seen.

Well defined terraces are seen in the Bear River valley, before this river enters Cache valley. There are three of different heights, which seem to correspond to three similar ones noticed in Salt Lake valley northeast of Brigham City. In the lake basin, again, one terrace is very clearly defined along the foot of the high peaks bordering the southeastern side.

Alluvium is found along most of the water-courses. The larger ones have usually a yearly increase, occasioned by the freshets of the melting snow, and here are almost the only surfaces in the hills and lowlands which sustain a luxuriant vegetation. The forks of the Laramie are bordered by rich alluvial bottoms, with grass and brush. Rock creek, Medicine Bow river, and the North Platte, are the water-courses east of the summit whose alluvium sustains also cottonwood. West of the summit, Green river, the lower part of Echo, and the Weber and Bear rivers, have the same characteristics. The Weber has two wide valleys among the mountains, which the Mormons have dotted with green fields of hay and cereals, that give them a delightful and refreshing appearance to the traveller in his westward course over the barren highlands of the mountain region. At Bitter creek the alluvium is mostly calcareous clay, and generally devoid of grass.

Vegetation.—The want of moisture which prevails throughout the region under consideration is strikingly attested by the absence of trees and brush in all the lower part of the country, except the few large valleys above mentioned, where moisture is derived from the running streams. The cottonwood trees found along the rivers are mostly old trees, which diminish in number year after year, from age, from the changing of the bed of the stream, and from prairie fires. It would seem that the time of their infancy was better adapted to the growth of young shoots than the present. Grass and sage brush (artemisia) are about the only forms of vegetation which the country can sustain by atmospheric moisture. Where the ground is favorable, and no injurious mineral matter predominates, fine and good grass is found in the valleys and on the bluffs bordering them; also, on the high lands. From Fort Sanders to the table lands beyond Rock creek, grass has almost exclusive possession of the ground, but from the last named point to the summit, and west of it, sage brush predominates. In the dry valleys or depressions, where spring streams have cut high banks in the hard, calcareous, clayish alluvium, and left some standing water, it grows sometimes above the height of man. The Red desert and the valleys of Bitter creek are unfavorable even to this kind of vegetation, but are overgrown with small bushes of "grease wood." The hills along the valleys of Green river are generally favorable to the growth of grass and sage brush.

The ranges of mountains sustain a growth of pine, cedar, spruce, fir and quaking ash. They are, as well as could be judged at a distance, thickly covered in some places, and in others only partially so, or bare. The Wahsatch mountains lack timber on the eastern side, but are covered in spots on the western. The Bear River mountains are generally very well supplied. The Wind River mountains have pines at certain heights.

Stones for building material are abundant. The portion which is destitute of them on the surface is the region between Fort Sanders and Rock creek.

The harder sandstones of the Rattlesnake hills afford very good building material, and there are some good outcrops at the crossing of the North Platte and in its cañons. Generally the same is true of the cañon of Pass creek. Material of very great strength and durability could probably be found on or at the foot of Elk mountain. Further west the quartzite, which occurs near Rawlins's spring, is one of the strongest and most durable materials known, while a few miles west of this point are sandstones of excellent quality. According to our present knowledge, the limestones in this vicinity will be valuable from the total want of this material between Fort Sanders and Bitter creek, beyond Salt Well station. It is, however, probable that limestone occurs on Bitter creek, near Laclede station, as fossil shells are found there, some of which are enveloped with limestone. There may be a lack of suitable rocks near the summit, and along the Red desert, but on the south and southwestern sides of it there are probably sandstones which will be available for building purposes.

On Bitter creek both the sandstone between the coal beds and the grits overlying them, especially the grayish sandstone, will be found of excellent quality. Good building material was seen at several points west of Green river. At Fort Bridger a good stone is found, and from thence west, after crossing the Muddy, to Bear river, there is no lack of it. Some limestones are found near Pioneer's Hollow. At the head of Echo valley there are limestones, but further down a great variety of sandstones, suitable for construction. In both the Weber cañons there is a large choice of very good material. North of Fort Bridger, beyond the Muddy, there is much sandstone of fair quality.

In concluding this part of the report, I will remark that the country can hardly be said to be good for agricultural purposes. The soil is rich in mineral matter, but comparatively poor in vegetable ingredients, except the alluvium of many of the water-courses, and some wide valleys in which the growth of grass has produced an accumulation of organic matter on the surface. In some cases the decomposition of calcareous clays forms a soil unfit for vegetation. The want of moisture which prevails is, however, the most formidable obstacle to vegetable growth. In cultivation this want could be supplied, on all water-courses, by irrigation, so that many parts of the country can still be made very productive. Since the wealth of the region under consideration lies mainly in its mineral resources, the good agricultural lands will probably be sufficient for the wants of the population, unless it be largely increased by the travelling facilities to be offered, and by the glitter of the precious metals; there being reason to suppose that to discoveries already made many will be added. It is also likely that, besides the precious metals, ores which have not thus far drawn the attention of enterprise will, by the facilities of communication, be found remunerative to capital. I will mention that the alkalies found so abundantly in some parts of the country may possibly be partially separated from their impurities and shipped further east for further purification, so as to obtain a pure carbonate of soda for the market. Soda springs is a locality which could also supply a great amount of this substance. The sulphur found near Soda springs, if it can be brought to market cheap enough to compete with the Sicilian, might be another article of export. The gypsum found near Medicine

Bow river, and near Laporte, deserves mention as having a certain value as a fertilizer and in the arts.

The third part of this report is particularly devoted to the coal beds occurring on the lines run by Mr. J. R. Maxwell, near the North Platte, and between that and Medicine Bow river.

Returning from Salt lake in your company, on reaching North Platte I was instructed to remain with Mr. Maxwell's party and search for and determine the value of any coal beds which might exist wherever the party should go in the performance of their work.

Having, in the second part of my report, given a general idea of the coal formations of this part of the country, this portion is devoted to the description of the several beds met with, their quality, quantity, facilities for mining, &c. Mention is also made of the iron ores found in connection with the coal beds. A map accompanies this, giving the approximate locality of each outcrop, marked with a red point, surrounded by a blue line, and numbered.

COAL BEDS.

No. 1 is a bed about one and a half to two feet thick, with an inch of gray shale on each side, and above and below this, hard sandstone. The dip of the bed is about 10° northeast. It is found in a small ravine on the northeastern side of the cañon through the Rattlesnake Hills, and in two or three ravines east of the end of the cañon.

No. 2, about a mile below the Rattlesnake Hills cañon, is another cut through the bluffs, presenting very precipitous banks on the left of the river. These banks at the entrance contain black ferruginous sandstone, with seams of coal and gray shales. The bed of coal and shale is about four feet thick, and lies between sandstones. The thickness of the coal itself is not over one and one-half foot; quality pretty good. One of these beds is probably the same as No. 1, as the strata apparently form part of an arch connected with the synclinal first mentioned.

No. 3 indicates the position of two other seams about one and one-half foot thick, found near the middle of the cañon mentioned in No. 2. They are of the same character as Nos. 1 and 2. The black bank at the end of the cañon is slate shale.

Nos. 4 and 5. About 1,000 yards to the right of stations 5286 and 5290 of line X, (along the North Platte and through the Rattlesnake Hills cañon,) is the mouth of a valley on the north side of which are ridges and small valleys running west-northwest. In the second and third valleys, about two miles from the river, are beds of coal. The first is from three to three and one-half feet thick; the second I could not measure. The dip is about 15° north-northeast. The coal is apparently very black and pure. It crumbles into small pieces after being taken out.

No. 6 is found on the north side of the mouth of the valley above mentioned, near the entrance to a ravine coming from the north. It is two and three-fourths feet thick; dip about 20° northeast. Red shale occurs about five feet above and below it. Above the shale is a laminated soft sandstone, a foot or two thick,

capped by two or three feet of hard ferruginous sandstone. The coal is of the same nature as No. 4, but firmer.

No. 7. Nearly opposite station 5280 of the same line are bluffs, with steep sides, in which coal occurs; thickness and quality not ascertained.

No. 8. In this vicinity are many coal outcrops, numbered from 8 to 15. They occur near the mouth of the valley in which Maxwell ran his line down from the summit between the Medicine Bow and the North Platte, on the latter stream, about a mile above the mouth of this valley, in which Nos. 8 and 9 are found. I have given a separate enlarged map of the spot. There are three beds in this ravine; one on a small branch, which I numbered 8. It consists of some 10 feet of coal and black shale; the coal I judge to be about seven feet thick, pretty good, but somewhat slaty. The next one (also numbered 8) is in the main ravine, and has the same character, though it looks better and purer than the first. It is probably the same bed in better condition.

No. 9. This is found two or three yards lower down the same ravine. The thickness is about six feet, but it is covered with soil and difficult to get at without much digging. The quality appears to be pretty good. The dip of Nos 8 and 9 is about 10° north-northeast.

No. 10. Coming out of the ravine mentioned above, on the same side of the river, on the right, are very steep banks. In these are two or three seams of coal of the same character as the above numbers. It is almost impossible to reach the place at present. The inclination of the strata is down the river, which, after washing the base of the bluff for 200 or 300 yards, leaves the right side of the valley and runs across to the left. In the middle of the valley, on the right bank of the stream, close to the water's edge, is a bed of coal partly covered by water. This is numbered

No. 11. It is somewhat shaly, but tolerably good.

No. 12 is found on the left side of the river, in a steep bank, nearly opposite No. 11. It is not accessible at present, and is probably No. 11.

No. 13 is on the right bank of the Platte, at the mouth of the valley followed by Maxwell's line from the summit. The bed is from two to three feet thick, and could not very well be reached at present.

Nos. 14 and 15 are on the left side of the same valley, about half a mile from its mouth. They are not good, judging from an imperfect outcrop.

Nos. 16 and 17. There is another valley four or five miles south of the one mentioned above, running to the Platte, with a ridge on the right. In this valley, two or three miles east of the Platte, coal beds one or two feet thick, of inferior quality, are found mixed with shale.

No. 18 is about 1,000 yards to the right of station 4906, (preliminary line.) Pretty good coal; about six feet thick. The bed is covered by one or two feet of laminated sandstone, over which lies a harder ferruginous sandstone.

No. 19. East of No. 18 is a high table land that extends to the valley through which the line passes, ending abruptly on the right side of it, with deep ravines on the southern and eastern slopes. On the south side, near the top, are two beds of coal of fair quality, three to four feet thick.

No. 20. On the eastern slope are two other beds, six to eight feet thick; quality similar to No. 18.

No. 21. Two or three miles south of the valley in which the line was run, that is, south of section 4750, preliminary line, there is another valley running nearly parallel to it. At its head is a wide basin giving origin to two streams; the larger, running south of a knoll, forms a deep ravine with grass and water; the smaller runs north of it and empties into the larger west of the knoll. The valley of these two streams is bordered on its western side by a ridge of ferruginous rocks; and again, about 1,000 feet further north, another ridge runs parallel to the first. In a north-northeast direction from the eastern side of the knoll there is a small ravine cutting the second ridge nearly at right angles. Following it 100 to 200 feet, a bed of coal will be found. The dip is from 5° to 10° north-northeast. It is seven or eight feet thick. The coal is hard, and has a conchoidal fracture. It took me nearly two hours to cut out with a hatchet a piece about a foot square.

No. 22 is near and above No. 21. It is not as good. I could not ascertain its thickness.

No. 23. In the first ridge mentioned, about midway from No. 21 to its extremity, in a ravine on the north side, is a great black spot in a hollow. This is a coal bed half removed. I could not ascertain its thickness. It is pretty good.

Nos. 24, 25 and 26. In the valley along which the line runs, on the other side of the summit, between the Medicine Bow and the North Platte, is an alkaline spring on the left side. Just below it a valley opens in a southerly direction, then, about two miles higher, turns in a southeasterly or nearly easterly direction. Here, near the top of the hills on the south, are two or three beds of coal. I could not ascertain much of their quality or thickness.

No. 27. On the eastern side of the same valley, not far from its mouth, I was told, after we had left the spot, that there was coal.

Nos. 28, 29 and 30. On the other side of the main valley, that is, north-northwest of the spring, is a ravine which contains outcrop No. 29. The coal is fair, but mixed with layers of red shale. At the entrance of a small ravine on the east side is an exposure of coal, (No. 28.) Its dip is about 8° northeast. It is covered by shale and sandstone, and is about six feet thick; its quality is good, but crumbling at the outcrop. Higher up the same ravine is a small branch coming in from the northeast. About 200 yards up this branch, in a deep cut on the east side, is found another bed, (No. 30.) This coal is hard, and looks like carboniferous bituminous coal. I dug into it about 1½ feet. It is hard to dig, and though wet, and its joints filled with clay more than a foot deep, it scarcely crumbled at all. It is four or five feet thick, with shale on top and sandstone over that.

Nos. 31 and 32. About half a mile higher than the above-mentioned spring, beyond an open valley, is a ridge on the north side. Here are two beds of coal, mostly covered. I did not ascertain their thickness. Their quality seemed to be fair.

Nos. 33 and 34. On the east of the summit, a little west of north of your

first camp, (after leaving the North Platte on your return,) about two miles distant, are hills between the forks of the alkaline creek. On the left side of these hills, between two ridges, there is some coal, of inferior quality.

No. 35. On the right, before reaching Nos. 33 and 34, is a coal-bed, with considerable sulphur, and about 200 yards further north, another bed, with less sulphur, and of better quality. It is about 5 feet thick.

No. 36. A few yards from No. 35 is a deep ravine, with a stream of water. In this is what seems to be good coal, but as it was mostly covered by hard soil, I could not get at it.

Nos. 37 and 38. In following Browne's line near and on this side of the summit, we passed through a cañon, (station 3491, location line,) beyond which a wide valley opens to the right, bordered on the west by hills. On the side of these hills, half-way up their slope, a mile north of the line, is a coal bed about one foot thick, of pretty good quality.

Nos. 39 and 40. By following the ridge of hills at the mouth of the cañon, (station 3490, location line,) which has a north, then a west-northwest direction, about two and a half miles from the cañon, the northeast extremity of the wide valley mentioned in Nos. 37 and 38 is reached. Here is a deep ravine, with a southwesterly course towards the valley. In one of its northeastern branches, near its head, is a bed of coal about six feet thick, of a quality similar to No. 30. It has shale above and below it, and yellow sandstone under this, but above the shale, strongly-colored ferruginous sandstone. The dip is 15° east-northeast. No. 40 is nearer to the line, but I did not examine it.

No. 41. Near the entrance of the cañon at station 3489+50, location line, about 100 yards from the mouth, on the right or north, is a bank of coal from six to seven feet thick; dip 50° east. It was very wet when I examined it. I dug into it about two feet. It seemed good, although at the surface it crumbled into small pieces.

No. 42. Over the hills on the right of station 3469, location line, is an outcrop of coal similar to No. 39. Both Nos. 41 and 42 should cross under the line, not far from the surface. There is danger, however, of their having been washed away.

No. 43. At the entrance of the same cañon, near its head, is a stream coming in from the south, just below a group of cottonwood trees. On the north is a slope with a bed of coal one or two feet thick, of fair quality.

Nos. 44, 45 and 46. Following the eastern slope of the Rattlesnake Hills, whose ridge commences on the southwest side of the cañon mentioned and goes thence westward, you come to a valley at the end of which is a lake. This valley is bordered on the east by high table lands, having small ridges parallel to it composed of ferruginous sandstone. Here are three or four places where coal would probably be found. I was not able to examine the spot.

Nos. 47, 48 and 49. Southeast of Rattlesnake Peak, which lies southwest of the cañon about eight and a half miles, there are three or four beds of coal. It was so late in the day when I saw them that I could not examine them.

No. 50. On the north side of Maxwell's line, near station 3200, is a ridge which contains three or four beds, from one to two feet thick; dip 25° to 30°

east-southeast; quality pretty good. In this vicinity are numerous springs, impregnated with sulphur and iron.

So far as can be judged by the outcrops of the beds enumerated, No. 21 is the best, in purity and compactness, but probably not the best considering its disintegrating property. No. 30 is less pure than No. 21, but holds together better. It is likely to contain seams of slaty coal. No. 39 is next in quality to No. 30, so far as compactness is concerned. Near to these in value are Nos. 8 and 11. It would be advisable to ascertain more fully the qualities of Nos. 6, 7, 9, 10, 18, 19, 20, 21, 23, 28, 36, 40, 41 and 42, in the bed.

The rock which overlies the coal-beds, even when of a hard sandstone, is usually cracked, and as a general rule the hard layers are few in number, while the mass of the strata consists of clayish shale, which is fragile; on this account it will be necessary to fully support the roof with timber. There is very little or no choice on this point among the beds of good thickness and quality which were examined. The coal being abundant, it will be a saving of timber to leave large pillars of coal to support the roof of the excavations. These pillars would have to support mainly a vertical strain; for although the dip of the beds is from 5° to 20°, it is thought, from the observations made, that the high dip does not often extend far before it lessens and becomes nearly horizontal, as is shown in the accompanying figure.

Iron ores.—Iron, in quantities to be worked, I saw in a ravine about a quarter of a mile northwest of coal-bed No. 2. There are here about 12 small seams, from three to eight inches thick, lying in a stratum of black shale, from 20 to 30 feet thick. As far as observed, these were mostly sesquioxide of iron.

Also over bed No. 11, on the bank of the North Platte, iron occurs in thicker beds and in greater number than in the first place mentioned. It lies in an argillaceous or marly soft shale. Besides these localities, near and between beds Nos. 8 and 9, iron is found in considerable quantities, mixed with calcite.

In the two localities first mentioned, the strata lie in a nearly horizontal position, and the iron is found a little below the surface, so that large quantities could be obtained by open-air diggings, (stripping.)

I will observe in closing, that the coal mentioned in the preceding pages is the same as that found through the Rocky Mountain region, that is, "brown coal," or lignite. Although there is a great abundance of it, there is a marked difference in the quality and thickness of the different beds. Some are very poor; others contain much sulphur; some break into small pieces very easily; others hold together better, breaking into large fragments; some have a smooth, conchoidal fracture, and look much like cannel coal, while others have shining

seams intermixed with slaty ones, having the appearance of ordinary bituminous coal. Coal of good quality is comparatively rare. On this account, it would be advisable to secure for the company such beds as include the better coals, and are most conveniently situated, both for mining and transportation. This is especially important on account of the eagerness with which outsiders have been taking up land on Rock creek.

Most of the coals recently examined are harder, purer and more compact than those I found last year. The difference exhibited by their out-crops is, in fact, so great that I have the greatest confidence in the value of some of those noted above. I believe that the objectionable properties of many of the coals met with further east will be so diminished, and the per centage of carbon so increased, that they will be found good fuel for locomotives, and applicable to all the domestic uses for which other coals are employed. It is probable that they may not be found adapted to smelting purposes, but it is only by trial on a large scale, and with other than outcrop material, that the properties of these coals can be ascertained with any degree of accuracy.

All of which is respectfully submitted:

Your obedient servant,

DAVID VAN LENNEP.

Distances from Missouri river.

Names of places.	Elevation.	Miles from Missouri river.	Distance between places.
North Platte river	6,408	673	.....
Rawlins's spring	6,671	687	14
Separation creek	6,650	700	13
Dodge's summit	7,122	720	20
Red basin	6,660	736	16
Summit	7,164	754	18
Bitter creek	6,685	769½	15½
Green river	6,145	822	52½
Divide between Green river and Black's Fork	6,480	830	18
Black's Fork	6,244	842	12
Mouth Ham's Fork	6,344	854	12
Mouth Muddy river	6,412	869½	15½
Summit of rim of basin	7,538	911½	42
Bear river	7,034	925	13½
Summit of Wahsatch mountains	6,822	943	18
Mouth of Echo cañon	5,568	967	24
Great Salt Lake valley, mouth Weber cañon	4,667	999	32
Great Salt Lake City	4,285	1,036	37